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1962 at the Southeastern Forest Experiment Station

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FOREST UTILIZATION

Outdoor Storage of Hardwood Pulp Chips

Now that pulpmills purchase increasing amounts of pine and hardwood chips from sawmills, information is needed on the effects of outside storage of chips on pulp yields and quality. A 1959 study showed that losses in pulp yield or quality were practically the same for stored pine chips as for stored pine roundwood up to 6 months.

Similar studies were needed to help solve problems associated with outside storage of hardwood chips. Are there differences by species, by compaction, or by continuous wetting? What are the effects of moisture content and temperature on outside chip storage?

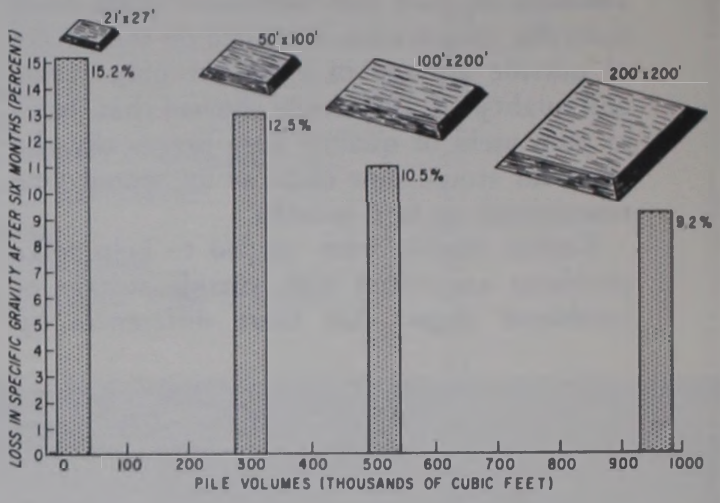
To answer some of these questions, a study of hardwood chips was made in cooperation with the Brunswick Pulp and Paper Company and the Georgia Forestry Commission. Chip piles on an asphalt apron were compacted by a crawler tractor. An oak chip pile contained about 100 cords, a gum pile about 95 cords, and another gum pile about 65. The smaller gum pile was thoroughly wetted during construction and sprayed continuously for 6 months.

Spreading and compacting a chip pile.

At the end of 1, 2, 3, 5, and 6 months, measurements were made of specific gravity, moisture content, fungus attack, and pulp quality. Temperature and rainfall measurements were made daily, and dirt counts were made monthly.

The study showed that wood losses during outdoor summer chip storage are higher in gum than in oak. Specific gravity losses in chip pile storage are reduced by compaction; thus, larger and thicker piles of chips are desirable. Comparisons between the experimental chip storage piles and commercial roundwood storage show less deterioration in oak chips than in roundwood but more in gum chips.

In general, the study indicated that hardwood chips can be stored outdoors for periods of 3 months without serious deterioration. Saturating a gum pile with water during construction and wetting it continuously thereafter was ineffective in controlling deterioration; total yield of pulp dropped after 60 days' storage; pulp strength losses, primarily loss of tearing resistance, showed a drop of 10 percent after 90 days of storage, not considered excessive compared to roundwood. Depending on local mill conditions, airborne contamination falling from mill stacks on unprotected chip piles can be the source of a serious dirt problem in bleached pulps; otherwise, there is no dirt increase associated with open storage.



Specific gravity losses are greater in small piles than in large piles.

Freshly exposed cross section in green gum pile after 5 months storage. Note heavy decay attack in side-slope areas.

Pretreating Southern Pine Turpentined Poles for Preservative Treatment

For many years longleaf and slash pine trees worked out for naval stores were accepted as poles only after the butts containing scarfaces had been cut off and discarded. Several studies had shown that poor penetration and retention of creosote occurred behind the pitch-soaked faces. Even the new methods of bark hacking and acid treatment, though reducing the pitch soak greatly, did not result in satisfactory preservative treatment, according to pole purchasers. Discarded butts have resulted in losses of as much as $50,000 a year at some treating yards.

In a preliminary test to improve penetration of turpentined faces, incising proved to be the simplest and most effective technique. A study was then made on 84 full-length longleaf pine poles (table 1).

Results of this and previous studies show that bark-hacked, acid-treated turpentined faces of longleaf and slash pine meet minimum standards of penetration and retention almost 100 percent of the time if poles are seasoned to an average moisture content of about 30 percent and then incised and steam conditioned before being pressure treated with preservative.

Incisions were made in parallel rows approximately 1 inch apart and running the length of the face. The vertical distance between incisions was about ½ inch. Depth of incision was ¾ inch, the length of the chisel-point tooth.

Table 1. --Penetration and retention of cores from full-length test poles, by groups

Lot number	Description	Average 1/ penetration of sapwood	Individual cores meeting A. W. P. A. requirements for penetration 2/	Average retention	Individual poles meeting A. W. P. A. requirements for retention 3/
		Percent	Percent	Pounds per cubic foot	Percent
I	Turpentined, seasoned 68 days, incised	97	95	14.42	100
II	Turpentined, seasoned 68 days, not incised	93	84	13.45	86
III	Turpentined, seasoned 29 days, incised	99	97	15.97	100
IV	Round, seasoned 68 days, not incised	100	100	13.23	95

1/ Calculated by adding percent penetration of each group of cores and dividing by number of groups.
2/ Calculated by adding number of cores meeting A. W. P. A. requirements and dividing by total number of cores involved.
3/ 7.5 pounds per cubic foot by extraction.

Hurricane House Design

Past studies have led to recommendations on ways and means of constructing beach cottages to withstand hurricane winds and water. Houses properly tied to piles driven at least 6-8 feet deep, with foundations, structural timbers, and roofs all bolted strongly together, have withstood severe conditions that damage or destroy other structures. The March 1962 northeaster that unexpectedly put water and sand over much of the Carolina outer banks further proved the soundness of previous construction specifications, and again demonstrated the resilience and durability of wood shingles, sills, framing, sheathing, and siding. Two new type hurricane-resistant houses with treated poles as an integral part of the house structure were constructed by E. E. Dargan, of Conway, South Carolina, according to his own and Station recommendations; these withstood the winds and water of Hurricane Ella without damage.

Hurricane house, with poles as integral part of structure. Note cable bracing, flush underside, and sill ties.

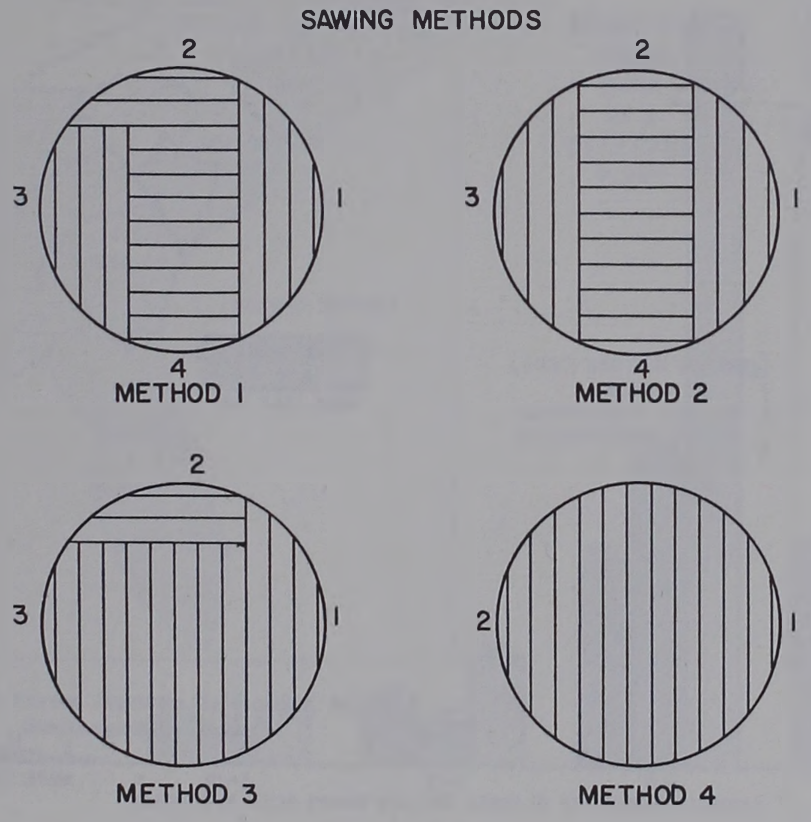
Hurricane house at Pawleys Island, S. C. The single, ground-floor room is designed to "go" at times of high water and severe storm without damaging superstructure.

Furniture Cuttings from Different Lumber Grades

Furniture manufacturers frequently ask which grade of lumber will produce the greatest amount of usable cuttings for their furniture. In an informal study at a North Carolina furniture plant, it was possible to study the yields from No. 1 common versus No. 2 common maple lumber. The clear cuttings suitable for table tops, drawer fronts, and end panels were 56 percent of the No. 1 common maple but only 15 percent from No. 2 common. Usable cuttings for parts not exposed in critical areas amounted to 71 percent for No. 1 common and 61 percent from No. 2 common. Such yields will vary with different plants and for different types of furniture, but the results clearly demonstrate why No. 1 common maple brings almost twice the price of No. 2 common.

Theoretically Sawing Pine Logs

A method was developed for theoretically sawing the same log an infinite number of times to obtain data for evaluating sawing methods and orientation of log defects to the sawing faces. Thirty-two shortleaf pine logs from the Whitehall Experimental Forest, of the University of Georgia, were theoretically sawn over 6000 times, and measurements were made each time of lumber grade and value of the lumber produced. Techniques were developed for using electronic data processing methods so that researchers could study four sawing techniques, sawing to three cant sizes, and applying several price structures. Since the logs sampled are from only one location and do not represent the full range in log characteristics or value, the results are primarily useful in the development of a technique and new methods of analyzing data.



Sawing methods studied.

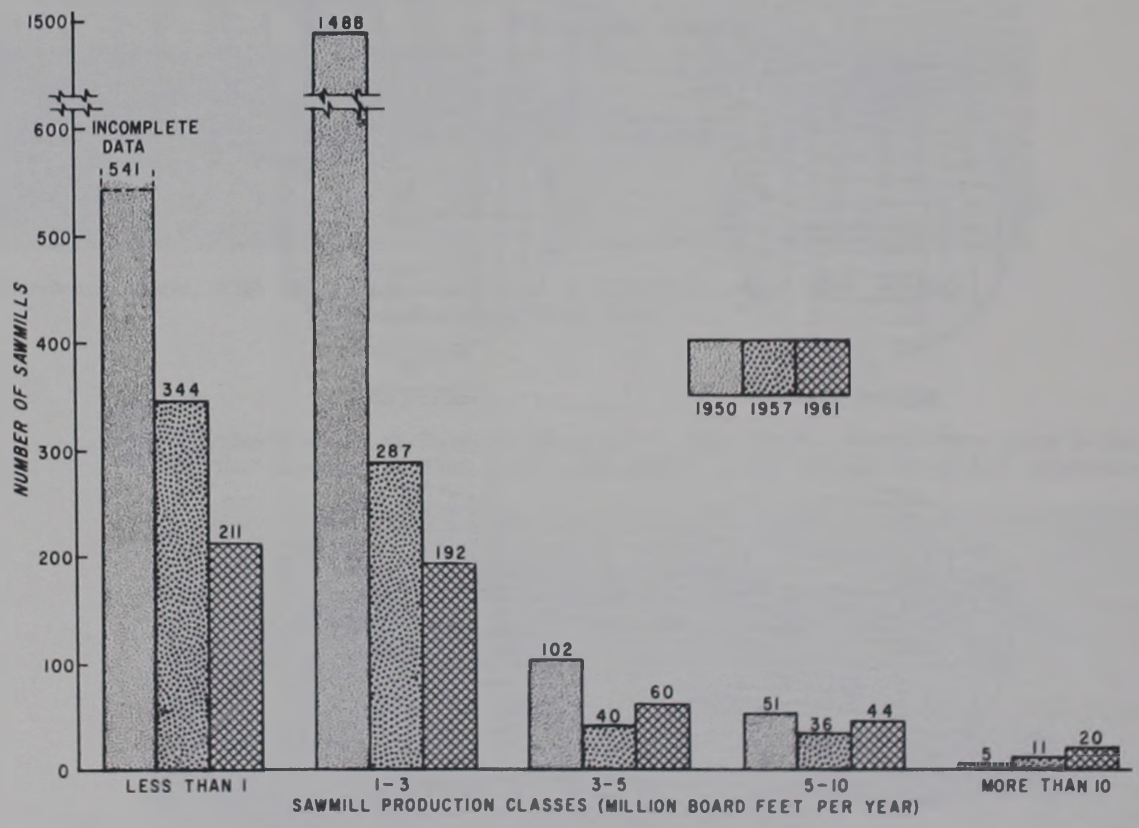
Results, for instance, show the wide difference in values that can be obtained from single logs by different sawing methods or the interrelationship of width and grade values when pine is sawn by four methods.

The technique opens new opportunities for testing changes in growth rate or silvicultural methods such as pruning. Such factors can be introduced into the log theoretically, and values determined immediately so that we do not have to wait many years until such logs could be cut and sawn.

Georgia Wood Using Industry Directory

A Utilization Report and Directory of Wood Using Industries in Georgia is thought to be the first publication in any state that covers all sawmills and even small wood cabinet shops. The 900 industries included were contacted primarily by members of the Georgia Forestry Commission, without whose cooperation the survey could not have been done. Many insights into the Georgia wood industry became apparent as the data were summarized and compared with previous studies. Much alarm had been expressed about the failure of many sawmills. The bar chart reveals the decline in small mills and the rise in large mills from 1950 through 1961. This report also shows the increasing use of pulpwood in Georgia and portrays the rising importance of hardwoods and wood residue.

Pertinent information is given about each of the Georgia wood using industries, including location, materials used, products sold, and size of operation. A listing of products manufactured and location of Georgia woodyards rounds out the report.



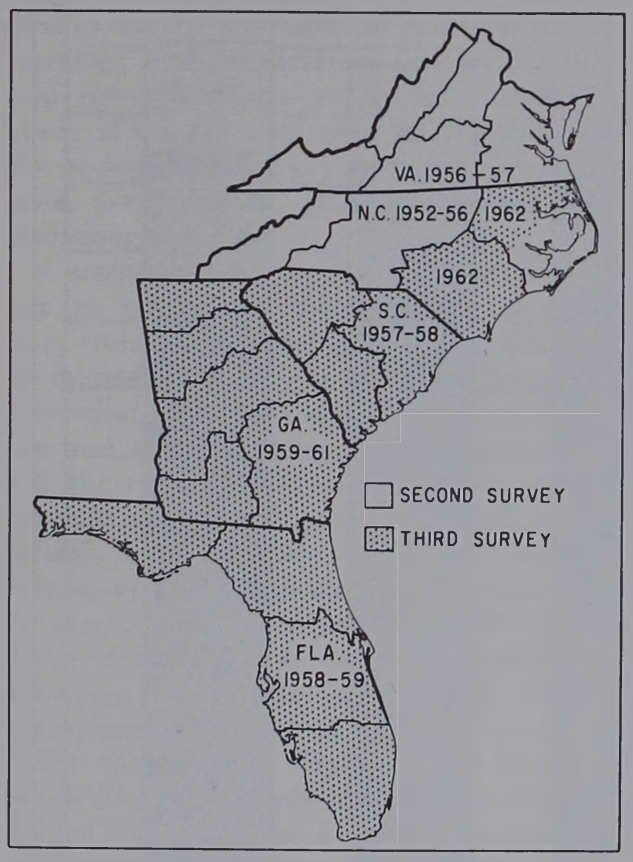
The number of sawmills by production classes for the years 1950, 1957, and 1961.

FOREST ECONOMICS

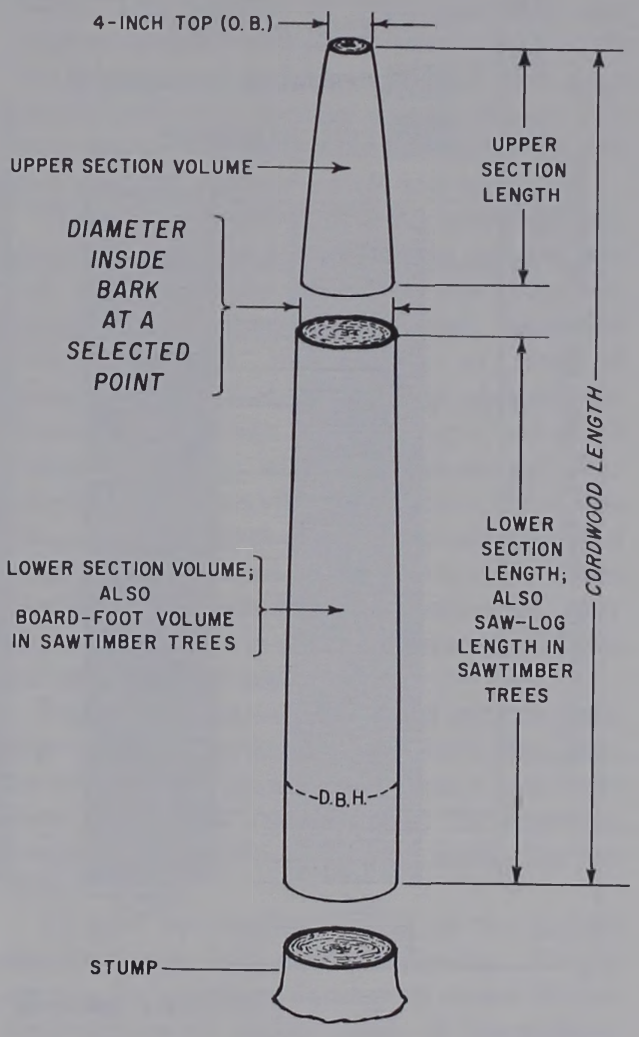
Forest Survey field work in the Southern Coastal Plain of North Carolina was completed in May and preliminary statistics for that area have been released. By the end of the year more than half the field work in the Northern Coastal Plain of North Carolina had been completed. Forest Survey assisted the Florida Forest Service in the preparation of a popular report issued by them entitled "Florida's Timber: Changes in Supply and Use." This report was based on data obtained from the three Forest Survey inventories of Florida.

A special volume equation study mentioned in the 1961 report was completed in July 1962 and the results issued as Station Paper 145. Initial tests of these new equations indicate that volume and growth estimates could be improved by their use, giving more precise estimates by using diameter inside bark at a selected point.

There are several advantages in using the new volume equation models over the simpler "D^2H" volume equation models: (1) Board-foot volumes for trees with short saw-log portions resulting from limbs or defects can



Status of Forest Survey field work in the Southeastern States.

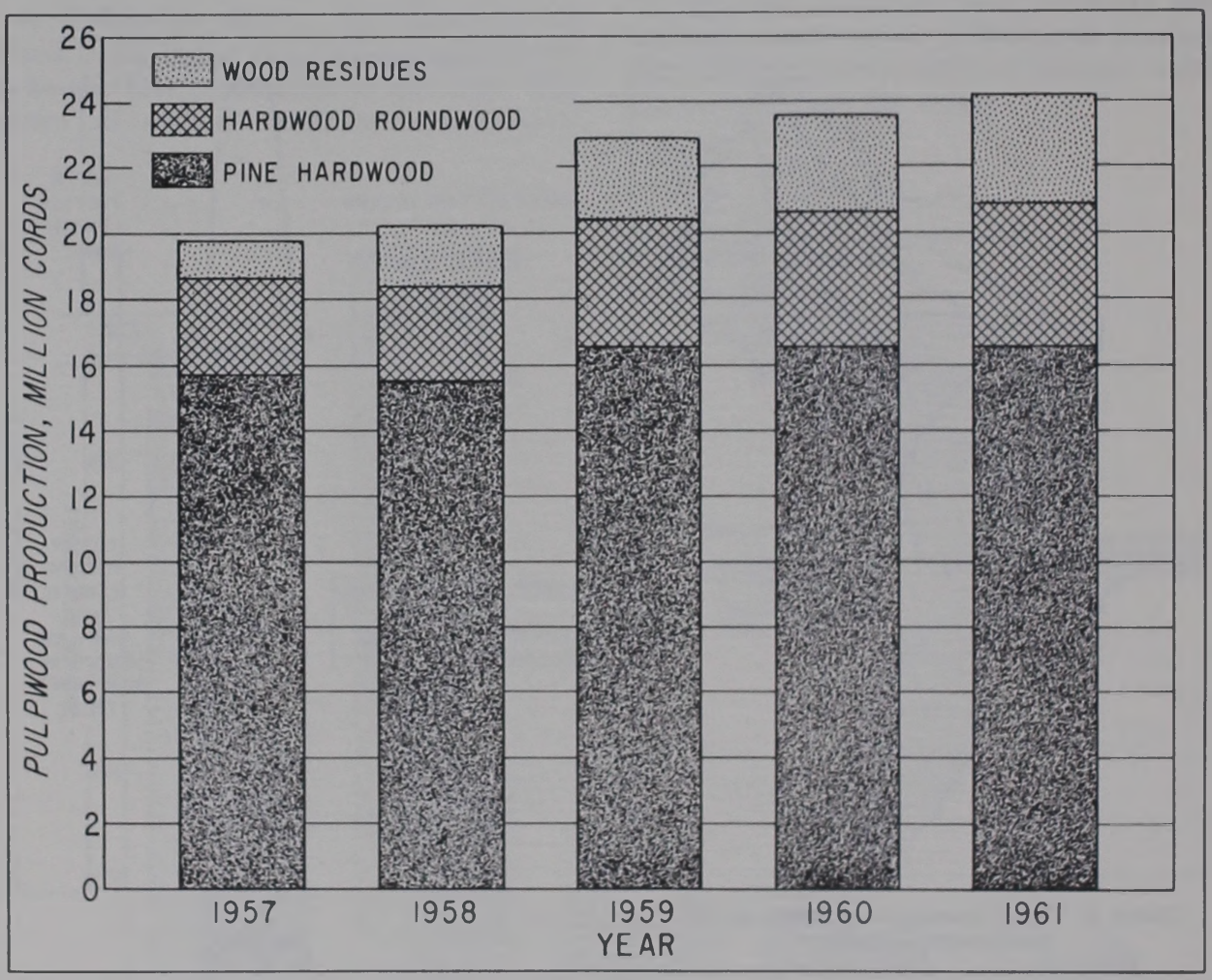

4-INCH TOP (O. B.)
UPPER SECTION VOLUME
UPPER SECTION LENGTH
DIAMETER INSIDE BARK AT A SELECTED POINT
LOWER SECTION VOLUME; ALSO BOARD-FOOT VOLUME IN SAWTIMBER TREES
LOWER SECTION LENGTH; ALSO SAW-LOG LENGTH IN SAWTIMBER TREES
CORDWOOD LENGTH
D.B.H.
STUMP

The diameter inside bark at a selected point, when used with d.b.h., cordwood length, and saw-log length, adds to the precision of volume estimates.

be accurately predicted; (2) cubic-foot volume of the saw-log portion of a tree can be predicted independently of the upper stem cubic-foot volume; (3) board foot-cubic foot ratios can be obtained for either the entire cubic-foot volume of the tree or the saw-log portion.

These new volume equations have been programed for use on a computer and the volume and growth for approximately 5.6 million acres of forest land in the Southern Coastal Plain of North Carolina processed.

The Southeastern and Southern Stations cooperated with the Southern Pulpwood Conservation Association on the seventeenth annual report of pulpwood production in the South. The output of over 24 million cords in 1961 was 60 percent of the Nation's total. Hardwood roundwood production, largely confined to central Virginia, western North Carolina, and southern Mississippi a decade ago, has spread into 176 additional counties as the number of mills using hardwood bolts increased from 34 to 64. Southeastern pulpmills paid a record $192 million for pulpwood during 1961. Prices for rough pine bolts and hardwood were down $0.10 a cord. Chip prices remained steady at $6.50 per ton for pine and $4.95 for hardwood.



Five-year pulpwood production in the South.

RANGE

INTEGRATED MANAGEMENT OF PINELANDS IN SOUTH GEORGIA AND FLORIDA

Opportunities in managing the piney woods for cattle forage, timber, and wildlife are being studied cooperatively at Tifton, Georgia, and Fort Myers, Florida, as reported in previous annual reports. Some key problems include: (1) getting increased production of quality forage yearlong for cattle and wildlife; (2) regenerating pine stands with minimum damage to young trees; and (3) maintaining forage and game habitat while timber crops mature. Researchers are learning how best to employ management practices such as burning, land preparation, and fertilization; and research efforts are being extended to study of soil-plant nutrient relationships and the ecology of some key species such as slash pine, saw-palmetto, gallberry, runner oaks, and slough grasses.

Current work is concerned with cattle damage to planted seedlings. Types of injury vary from light browsing of sapling-size trees to immediate killing of small seedlings. Intermediate between these extremes are browsing and mechanical injuries which may not kill the tree outright but affect its growth, form, or subsequent survival. Cattle eat the foliage, new shoots, and buds; and they peel, bruise, or break the stems and new shoots by trampling and rubbing them. While both types of damage may occur in combination, browsing tends to be seasonal, whereas trampling may occur anytime.

On the Caloosa Experimental Range in south Florida, a study of cattle stocking has helped document the nature and magnitude of damage to pines planted in wiregrass range units grazed at varying intensities. Both the common slash pine and the South Florida slash pine were planted in native pastures stocked to afford 33, 20, or 15 acres of grazing per cow per year. Age of the "rough" (accumulated herbage ground cover) varied, i.e., one set of ranges was burned just prior to planting, and another set had been burned a year earlier.

Most of the grazing damage was on the heavily grazed range units, particularly units burned just prior to planting. Much of the damage occurred immediately after planting, with only minor occasional injuries thereafter over a 3-year period of observation. Some of the early injuries, nevertheless, produced trees of poor form and growth habit. The number of trees damaged and relative severity of injuries were considerably less where trees had been planted in a grass rough; and total damage sustained over a 3-year period was quite nominal under the low and medium rates of cattle stocking.

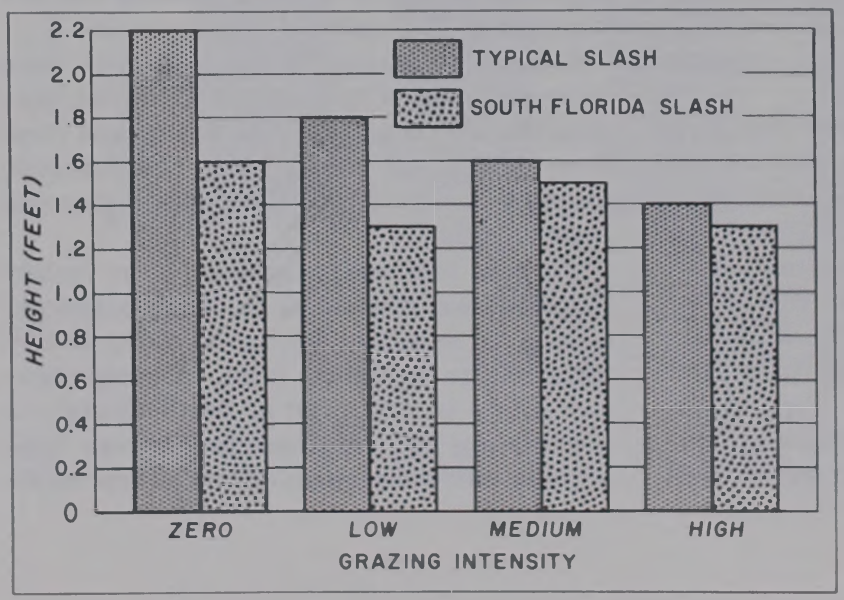
Three-year survival of pine seedlings was about the same under no grazing and the low and medium rates of cattle stocking, but significantly greater under high intensity grazing. Age of grass rough at time of planting was a factor—survival of seedlings planted on a recent burn averaged about 13 percent less than when planted on a 1-year rough. On the heavily grazed units there was 79 percent survival of seedlings planted in a rough, as compared to 45 percent for those planted on recent burns. There were only slight differences in survival between the two varieties of slash pine.

Impacts of grazing on height growth were most pronounced for common slash pine, particularly where grazing was heavy and trees were planted on recent burns. In contrast, height growth of South Florida slash pine was little affected.

To gain real understanding of the factors involved, we shall need to develop sharper criteria for assessing damage in terms of ultimate effects on timber yield. A comprehensive study of this type in south Georgia is interpreting the relationships between type of injury and subsequent effects on tree survi-

Poorly formed slash pine after injury by cattle.

Pine survival was poor when planted on heavily-grazed recent burns (immediate foreground).



Grazing impacts on height growth were more severe for typical slash pine than for the South Florida variety.

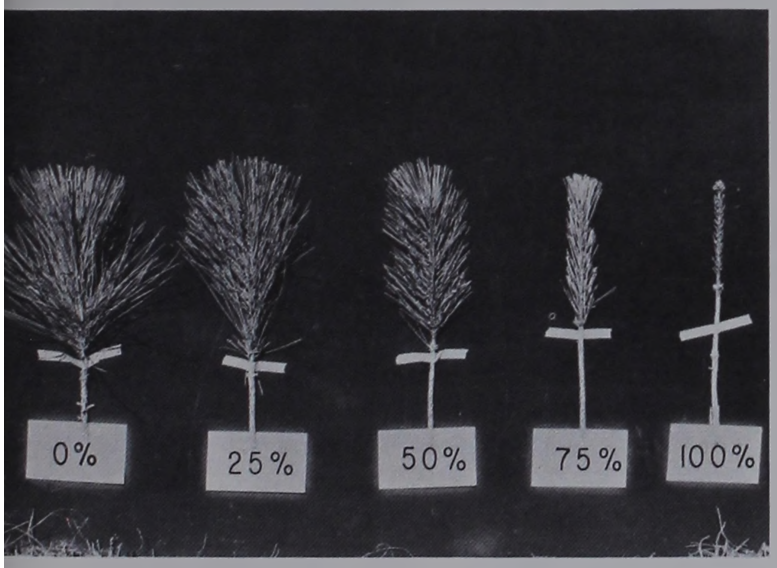
val and growth. Grazing injury to trees is simulated by carefully controlled levels of needle and shoot removal, stem breakage, and stem girdling. Treatments are applied during the first flush of spring growth on test trees at ages 1, 2, and 3 years after planting. Treatments will not be fully established until 1964, but the records are complete for first-year survival and growth of slash pine planted in 1960, 1961, and 1962.

Simulated browsing of as much as 75 percent of the foliage has not affected survival of first-year outplants, but removal of only 25 percent of the foliage definitely slowed seedling growth from 9.9 inches to 8.8 inches. Height growth was slowed by about 0.4 inch for each additional 25 percent of foliage removed up to and including 100 percent removal.

Shoot removal likewise did not influence survival but strikingly reduced growth. And simulated trampling—bending the stem over at a right angle to the ground — reduced seedling survival and growth about 10 percent.

Rather surprisingly, girdling or peeling of the main stem near ground line (removal of bark, inner bark, and cambial layer from a strip 2 inches high) to simulate hoof injury did not kill pine seedlings provided they were less than fully girdled. Height growth, however, was reduced commensurate with degree of girdling.

Removal of a 2-inch strip of bark and cambium simulating injury by cattle hoof.



Slash pine needles clipped to simulate cattle browsing.

Combined treatments involving foliage removal, shoot removal, and stem breakage on 1-year-old seedlings killed additional trees; and the mortality increased with severity of treatment, as shown in the following tabulation:

Stem treatment	*Foliage removed*		
	None	*½*	*All*
	(Percent survival)		
No stem breakage	100	98	68
Stem broken	80	77	31

FOREST RECREATION

Well known are the difficulties of tallying squirrels, fish, trees, beaver, etc. to estimate the populations being worked with. Not so well known are the problems in counting people and thus estimating human recreation activities on forest land.

The study of dispersed recreation use was begun in June 1960. Objectives were to develop sampling methods for estimating uses on large units of land, and to pilot-test these procedures on a 100-square-mile section of the George Washington National Forest in Virginia. Estimates of recreation use were obtained by interviewing people who use the Forest. To accomplish this, an arbitrary boundary was placed around the selected area and all exits classified into three major groups—paved roads, unpaved roads, and trails. All possible exits and all possible hours were randomly sampled for a 1-year period, June 1961 to June 1962. Roadblocks were set up on the paved roads for 1-hour periods, on unpaved roads for 2-hour periods, and on trails for 4 hours. Each party leaving the area during a sampling period was interviewed, and questionnaires were completed for each household represented.

Questionnaires were completed on forest recreationists as they left the area. Over 1,500 questionnaires were completed during the year in the Virginia study.

During the year more than 1,500 parties were interviewed, with results that provided a good estimate of total use on the 100-square-mile unit. Total area use—commercial, residential, and recreational—was 833,268 man-hours, or some 23 man-hours per square mile per day. Of the total, 83 percent (691,806 man-hours) was devoted to some form of recreation activity. Dispersed recreation such as hunting and fishing accounted for 275,688 man-hours, or 40 percent of total; and camping and picnicking on the developed recreation sites made up 26 percent. The analysis also shows that permanent private camps in this area were an important source of recreation, accounting for 34 percent of the total.

A second major study to provide ways of measuring camping, picnicking, boating, and swimming use was installed in 1961 and later extended to 13 developed sites on National Forest units in the South. Estimates were obtained by establishing a ratio of man-hours of use to traffic counts by simultaneously measuring both. Pneumatic traffic counters were used at all entrances to recreation sites to obtain total vehicle crossings for each 24-hour period during the 66-day recreation season (Fourth of July to Labor Day). The number of people in the area and the recreational facilities they used were tallied between 10:00 a.m. and 10:00 p.m. on selected days during the 66-day period. Five

Deer hunting on National Forest land was found to be a heavy, dispersed recreation use in the Virginia study.

areas were sampled intensively, with 8 weekday and 8 weekend or holiday samples, and eight areas were sampled on 4 weekdays and 4 weekends or holidays. During each hour of a 12-hour sampling period a count was made of the people and what they were doing. A ratio was then worked out between traffic counts and recreation uses on the sampled days. On days when a staff man was not actually present and counting people, we depended on traffic counters only to estimate uses. The data show that traffic counts and partial sample counts of people and uses will give reliable estimates of all kinds of season-long activity at the developed sites.

These simple, inexpensive inventory methods can be readily applied and easily interpreted by those charged with recreation management on forest areas. The estimates of highly variable and scattered recreation activities afford valuable use statistics heretofore unavailable; and the need for reliable estimates centering on the developed sites is almost as critical.

Traffic counters afforded reliable estimates of this type of family recreation.

WILDLIFE

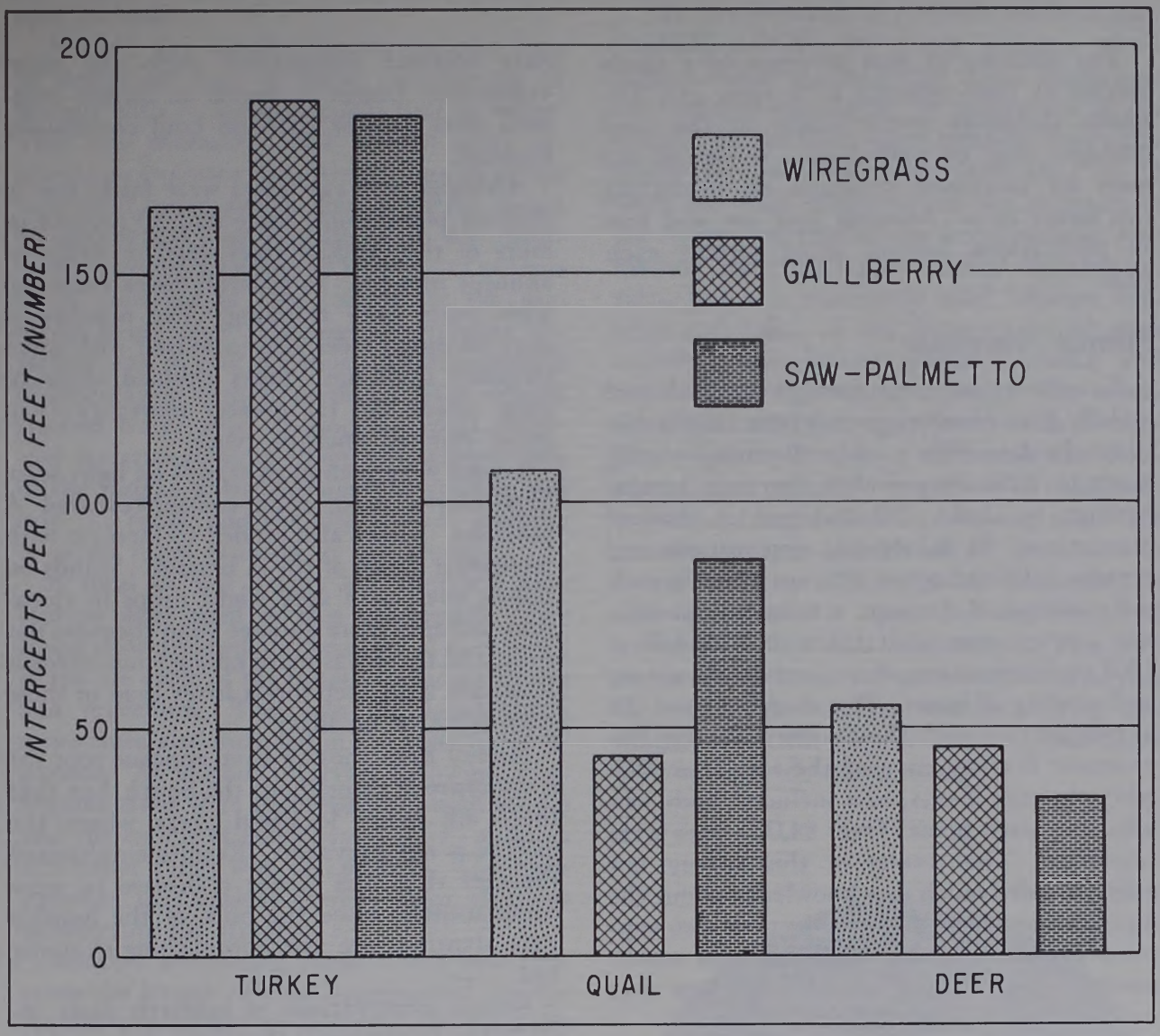
Totaling some 8 million acres and extending from the Carolinas to central Florida, the flatwoods country (including the slash-longleaf pine type) is a major producer of timber and forage, but is not generally regarded as an area of high game productivity. In recent years, some work has been directed toward study of its capacities and potential for food and cover production, but not much is known about the occurrence and ecology of the principal understory plant species.

A comprehensive study to assess long-term effects of land preparation treatment on growth and survival of planted pine has been under way several years in cooperation with the Georgia Forest Research Council, the Georgia Forestry Commission, and the five industries, Brunswick Pulp and Paper Company, Owens-Illinois Glass Company, Rayonier Incorporated, St. Regis Paper Company, Union Bag-Camp Paper Company. This study was organized under sponsorship of the Forest Game Research Committee of the Southeastern Section of the Wildlife Society, with direct participation in field phases by the Georgia Game and Fish Commission and the Florida Game and Fresh Water Fish Commission. The main approach has been to measure the changes in lesser vegetation as pine stands develop. Plots are analyzed before and after site treatment (four levels of mechanical scarification in combination with a standard burn).

Making the initial inventory of lesser vegetation on plots scheduled for variable site preparation treatment before planting to slash pine.

Plot areas mechanically scarified in varying degree.

Initial plant frequency data collected over a 2-year period from 500 transects on 100 plots distributed throughout the slash-longleaf flatwoods of north Florida and south Georgia afford some interesting comparisons for the three main understory types, i.e., wiregrass, gallberry, and saw-palmetto. The data, though preliminary, suggest that flatwoods communities are somewhat more productive for quail than for deer, but most productive for turkey. For the most part, there are significant differences between the understory types for all three game species. The exception: for quail, wiregrass and saw-palmetto are about equally productive, with the gallberry type rated low in this respect. For turkey, the saw-palmetto and gallberry types are most productive because the fruits are staple turkey foods. Though all types appear somewhat marginal for deer, wiregrass and saw-palmetto are the more productive.



Relative frequency of desirable game food plants in three subtypes for quail, deer, and turkey.

Data collections will be made later to trace successional patterns and trends as these reflect important habitat changes and help characterize long-term effects of major site disturbance in the flatwoods slash-longleaf type. Although studies to assess impacts of large-scale cultural practices now occupy a major share of Project effort, the new work will increasingly be concerned with studies of environmental factors and relationships. Through this avenue of attack, search will be made for basic cause and effect relations as the best guide for managing key species and plant communities.

FOREST DISEASES

The planting of vast acreages to a single species at close spacing with early and frequent thinnings spells profit to the land manager, but to pathologists it signals the need for increased emphasis on protecting the forest crop. Annosus root rot and rust in plantations become more serious each year.

Fomes Annosus

F. annosus root rot damage to slash and loblolly pine plantations has been on the rise since the late 1950's. A preliminary survey made in 1960 showed that the most serious damage to slash pine occurred in thinned plantations. As subsequent observations and reports indicated grave concern about potential widespread damage, a more comprehensive survey was undertaken in the fall of 1962 to determine more accurately the extent and severity of losses. This study, carried out in conjunction with the Southern Forest Experiment Station, covered the area from Virginia through Texas, and included both loblolly and slash pines. Over 84,000 trees were examined. The results of this survey not only provided much new knowledge about the distribution of the disease, but they also supplied pathologists with valuable and much-needed leads on some of the conditions that may control its development.

The survey confirmed previous findings that losses in natural stands were low, and that thinned plantations were the most vulnerable. Losses in stands on former cropland were greater than on land continually forested.

Although average losses were fairly low in thinned plantations, some had 30 percent or more of the residual trees dead or dying of annosus root rot. In general, losses increased with years since thinning. The number of dead or dying trees also increased with more frequent thinnings. Plots thinned three or more times had far greater mortality than those thinned once or twice.

Losses were greater in stands on light soils, particularly those with coarser-textured A horizons. Losses also tended to increase with increasing depth of the A horizon. Stands on slopes, even with very slight drops in elevation, suffered more damage than those on flat sites, and there was more killing from annosus in stands with deep forest litter than in those with little or no litter.

Survey data showed that annosus root rot is widespread throughout the South, but that there are many localized areas where the disease is not prevalent. Results emphasized the fact that this is not a disease to view complacently, since the bulk of the South's vast plantings are just approaching thinning age.

Recent observations of research plots installed in 1959 suggest that damage caused by *Fomes annosus* root rot is likely to increase over the years (table 2). The increases in

Table 2. --Increase in annosus root rot damage over a 3-year period

Plot location	Age of stand	Original spacing	Number thinnings	Percent infected 1959	Percent infected or dead 1962
South Carolina	23	5 x 8	2	11.5	26.9
South Carolina	25	6 x 6	1	5.4	35.1
South Carolina	23	6 x 6	2	24.3	40.5
Georgia	22	8 x 15	1	35.3	47.1
Georgia	27	15 x 15	1	13.3	13.3

infection in four of the five plots over a 3-year period are significant. Only the plot with 15 x 15 spacing has no increase in disease incidence.

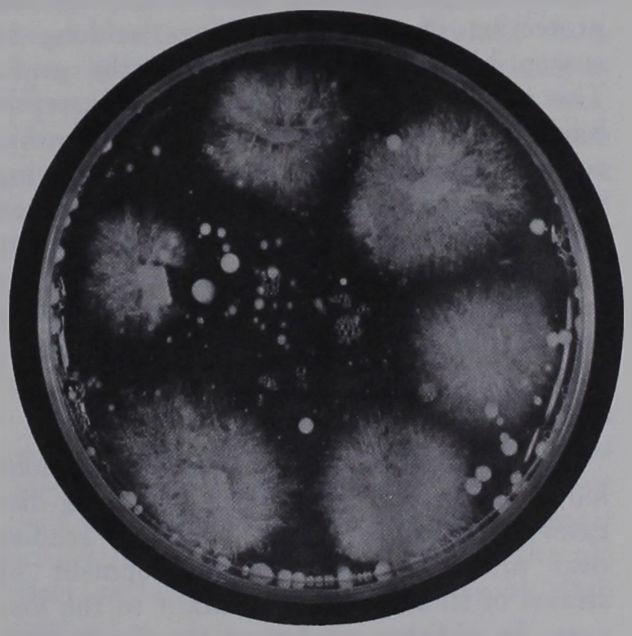
A study was installed during the past year to determine how artificial inoculations of stumps with *F. annosus* could best be made. This was necessary since several early attempts to evaluate the effectiveness of stump treatment failed, not because of faulty design or installation, but because there was insufficient natural infection of freshly cut stumps by *F. annosus* to test adequately the materials being used. Although the primary objective was to find the most suitable method of inoculating with *F. annosus*, other aspects studied were: type of inoculum that colonized the stumps most effectively, growth rate of the fungus down through the stumps and into the roots, and the effect on *F. annosus* of other fungi growing in the stumps.

A total of 500 freshly cut shortleaf pine stumps were used in this experiment. The inoculation treatments consisted of each stage in the life cycle of the fungus including spores and mycelium. Two non-inoculated check series were also included in the tests for comparison. At various intervals following inoculation, slabs were removed from each stump and the extent of colonization by *F. annosus* and other fungi was determined. The basidiospore inoculations proved most effective in infecting the stumps.

Another interesting result of this test concerns the length of time unprotected stumps remain susceptible to infection. It has been assumed that this period is relatively short. The data from this test showed that the infection of non-inoculated stumps continued over a period of several months, so that after 6 months the percentage of infection in the check series equalled that of the inoculated stumps.

Our studies of the rate of fungus growth down through the stumps showed the average penetration after 3 months was 2 inches, 11 inches after 6 months, and 30 inches after 10 months. It also showed that fungi other than *Fomes annosus* often invade and rapidly colonize the stumps. These fungi compete with annosus for food and have a profound effect on the survival of *F. annosus* in the stumps. This in turn is directly related to the ability of annosus to spread to adjacent healthy trees.

The development of a culture medium particularly suitable for direct isolation of *F. annosus* from infected host tissue made possible critical studies on the movement of the fungus. In the past, wood samples were commonly incubated in moist paper for 7 to 14 days and then examined for the presence of the fungus growing on the wood surface. This method sometimes gave highly variable results, but was commonly used because bacteria and fungi in the decaying wood grew rapidly on ordinary synthetic media and overran the *F. annosus* colonies. The newly developed selective agar medium is a complex mixture of selected chemicals and antibiotics that restricts the growth of most bacteria and fungi found in decaying roots but permits normal growth of *F. annosus*. In fact, *F. annosus* colonies are so distinctive on this medium that they can be identified without the use of a microscope. This new medium will assist all pathologists studying *F. annosus* in isolating and identifying this fungus, and will greatly improve the accuracy of their determinations.



Fomes annosus growing from infected stump tissue. Note restricted growth of other fungi and bacteria in the plate.

During 1962 two long-term studies on annosus root rot were established: (1) a Southwide study to evaluate the effectiveness of creosote and ammonium fluoride as stump protectants in preventing the establishment of *F. annosus* in a stand and (2) a replanting study on sites heavily infected with *F. annosus*.

Fusiform Rust

Data taken by the Georgia Forestry Commission at the Horseshoe Bend and Arrowhead Seed Orchards showed that approximately 20 percent of over 14,000 grafted trees in these nurseries were infected by fusiform rust at or near the graft union. Rust infections were particularly abundant at the Arrowhead Seed Orchard, where approximately 39 percent of the loblolly and 25 percent of the slash pines were infected.

Study of these infections by the Southeastern Station revealed that most had originated on the stock plants and spread into the graft unions. The infections on the root stocks were apparently in the incipient stage and escaped detection at the time the grafts were made. Infections were less numerous on trees grafted to potted stock in greenhouses and planted in the orchards later in the season.

Experience with fusiform rust in these orchards emphasizes the need for fungicidal protection of grafted seedlings as long as susceptible foliage exists below the graft. This is particularly important since susceptibility of the root stock bears no relationship to the resistance of the scion materials being tested. Later on, after the tree is composed entirely of scion growth, such protection may be undesirable because susceptibility or resistance of the selected scion material is one of the properties being tested.

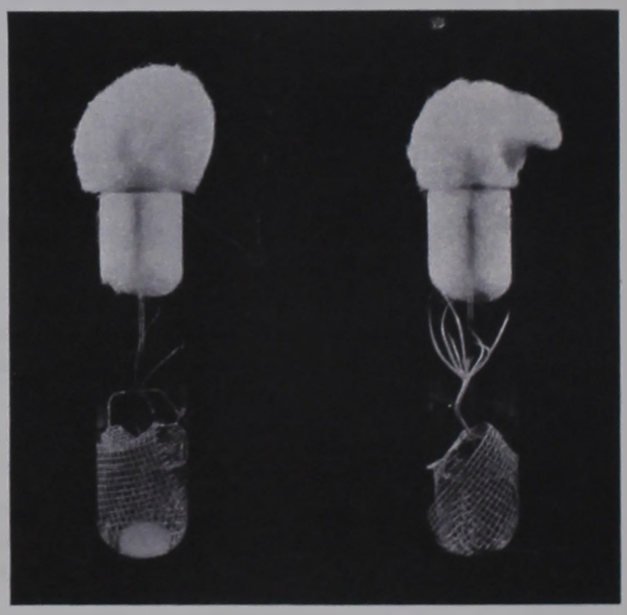
Littleleaf

The littleleaf disease of shortleaf and loblolly pines is one of the most damaging diseases in southern forests. Current studies deal primarily with the development of strains of shortleaf pine resistant to the disease. In addition, studies on the distribution of the causal fungus, *Phytophthora cinnamomi*, and its survival under various soil conditions are being continued.

Our breeding program involves two major areas of work: (1) crossing clones of shortleaf pine selected for resistance to the littleleaf disease, and (2) development of methods for testing the resistance of seedlings to *P. cinnamomi*. Crosses made in this breeding program during 1961 were apparently 20 percent successful. During 1962 a total of 677 single-cross pollinations were made within and among clones. Seed from these crosses will be available for testing in 1964.

Earlier attempts to evaluate seedling resistance were hampered by lengthy and difficult testing procedures. In order to screen critically the progeny from the crosses made during 1961 and 1962, we are trying to devise a method for handling and testing large numbers of seedlings under controlled conditions so that root systems can be readily examined for evidence of resistance or infection.

P. cinnamomi seems to be very long lived under field conditions after artificial infestation. In 1939 a number of red pine seedlings



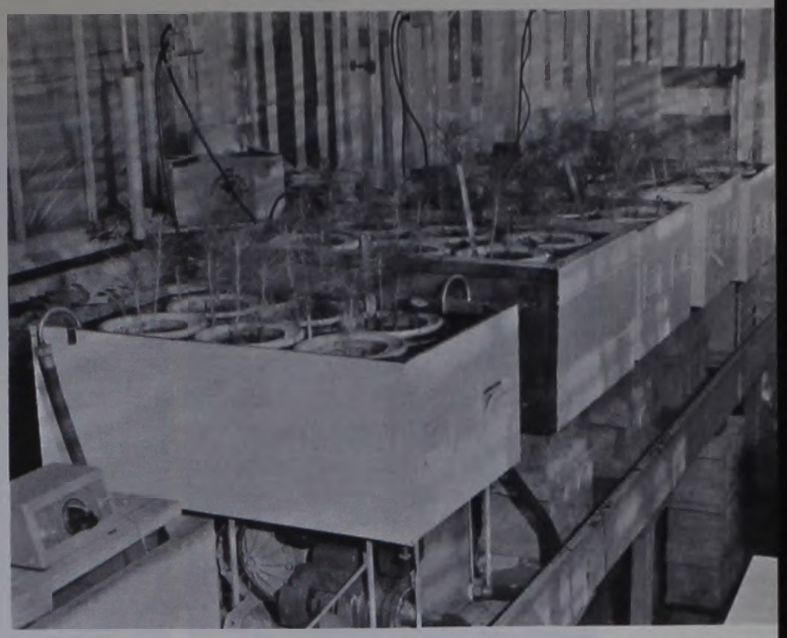
Shortleaf pine seedlings are grown in test tubes containing distilled water and a stem support and root "toe-hold" made of folded fiberglass screen. Each tube is inoculated with an agar culture disk of P. cinnamomi-bearing sporangia. Zoospores are released from the sporangia when the disk is placed in distilled water in which the seedling root is growing. The root system of the seedlings can be examined microscopically at any time for evidence of infection. Seedling at left has been killed by Phytophthora cinnamomi.

were planted near Athens, Georgia. On June 16, 1948, 6 of the trees, then 3 to 5 feet tall, were inoculated with *P. cinnamomi.* Inoculation reports show that the bark was "injured slightly at the root collar, the inoculum pressed against the wound and held there by packed soil." On November 1, 1948, the trees were recorded to be healthy. On October 9, 1962, all of the trees in the stand were examined and observed to be healthy. The largest specimens measured approximately 21 feet tall and up to 6 inches d.b.h. Samples of the soil from the feeder root zone of the trees, assayed by Campbell's apple technique, were found to be 95 percent positive for presence of *P. cinnamomi.* A similar assay of the soil only 50 feet upslope and samples from the root zones of shortleaf and loblolly pines growing there did not show the presence of *P. cinnamomi.* These results are significant from two standpoints: (1) red pine, reportedly susceptible to attack by *P. cinnamomi,* has survived for 14 years with the pathogen present in the feeding root zone, and in addition was not damaged by a severe type of inoculation; and (2) the artificially introduced pathogen has survived in the soil for 14 years.

Nematology

A general survey of nurseries, plantations, and natural stands was made in 1962 to determine what nematodes are associated with diseased and healthy forest trees. One problem area near Alexander, Georgia, in a 5-year-old slash plantation showed that root-lesion nematodes were associated with root damage and were probably contributing to the severe stunting in large areas of the plantation.

The American dagger nematode, *Xiphinema americanum,* is the most prevalent parasitic nematode found in forest soil samples to date from Florida to Pennsylvania. It has been found associated with shortleaf, longleaf, slash, loblolly, eastern white, red, and Virginia pines, and various southern red oaks. Studies to determine the ability of this nematode to feed and reproduce on slash pine are under way.

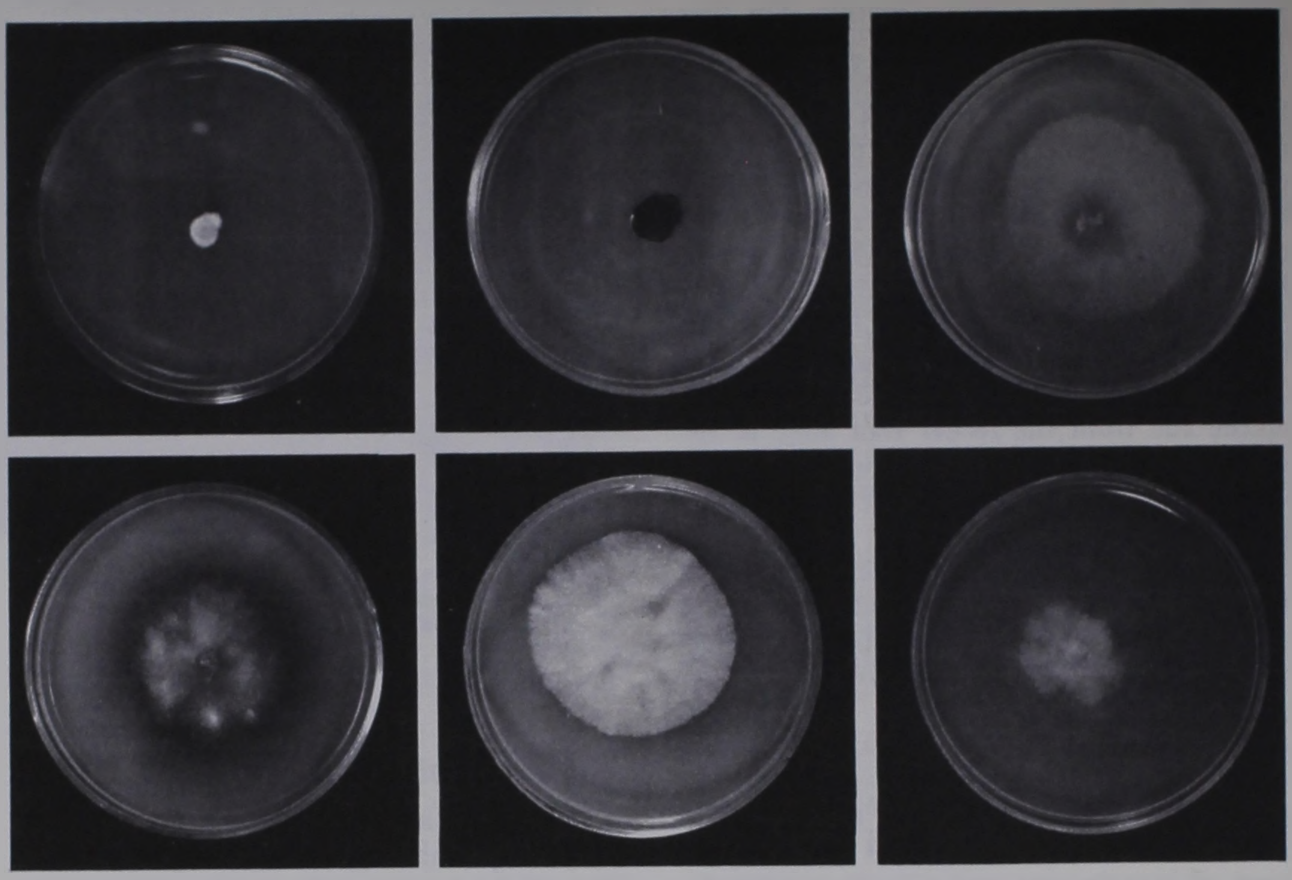


Temperature tanks used for the feeding and reproduction of the American dagger nematode on slash pine seedlings.

Mycorrhizal Research

Many forest biologists believe that the fungi responsible for the mycorrhizal complex of forest trees are common mushroom types found fruiting in the forest litter after rainy periods. Recent investigations have demonstrated that many different fungi, mostly basidiomycetes, are involved in the mycorrhizal complex of slash pine seedlings. These fungi, isolated directly from the mycorrhizal short roots, differed culturally from those of numerous mushrooms obtained at different times from the same forested area. This indicated that the fungi which form mycorrhizae with roots of forest trees are not necessarily the commonly encountered mushrooms, but rather species which are very inconspicuous or rarely if ever fruit. Many different mycorrhizal fungi are apparently responsible for this symbiotic relationship within a limited forest area.

The degree of soil acidity, or pH, has been suspected of influencing the occurrence of different mycorrhizal associations in forest trees. Methods of stabilizing the pH in aseptic culture flasks were devised to study the pH effect on formation of mycorrhizae on slash pine.



Some dissimilar fungal isolates recovered from slash pine mycorrhiza in a limited forest area.

It was found that slash pine seedlings grown with *Boletus luteus*, and those with *Cenococcum graniforme*, exhibited best height, weight, and root measurements at pH 4.0 to 4.6. *C. graniforme* stimulated the seedlings to produce longer lateral roots with more short roots, thus contributing significantly to seedling growth. This is the first report of this fungus-forming mycorrhizae with a southern pine in synthetic culture. Seedlings grown with *Clitocybe laccata* had the greatest number of mycorrhizae but were not significantly better in most growth measurements than the other two seedling groups. It contributed more to the over-all growth of the seedlings at pH 4.6 to 6.6. Slash pine seedlings grown free of mycorrhizal fungi developed best at pH 4.6 to 5.6 under the aseptic culture conditions, but were not as vigorous as the mycorrhizal seedlings.

Nursery Disease Research

Greenhouse studies to determine the effectiveness of several fungicides in controlling damping-off of slash pine seedlings showed no significant differences between preplanting treatments and applications made after disease symptoms appear. When applied at a rate of 150 pounds per acre after the disease appeared, Terracap, the most effective material tested, reduced seedling mortality to 24 percent. By comparison, seedling mortality was 68 percent on the untreated check plot.

A new nursery disease of Fraser fir was discovered at the Holmes State Forest Nursery near Hendersonville, North Carolina. The disease, a root rot caused by *Phytophthora cinnamomi*, resulted in the loss of nearly 50 percent of the 2-1 stock in the nursery. When isolations were made from diseased seedlings on a selective medium, *P.*

Root system of diseased Fraser fir on left contrasted with normal plant.

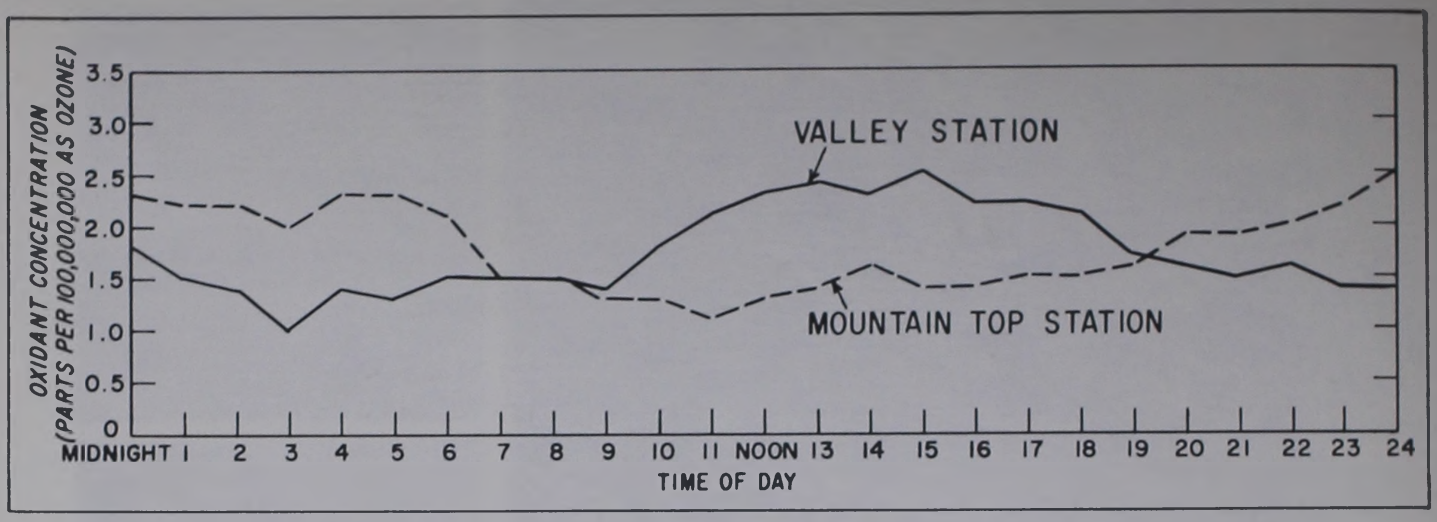
cinnamomi was recovered from 45 percent of 152 root sections. The fungus apparently entered the small roots and worked upward to a point 3 or 4 inches above ground. The cambial region over the entire affected area had a red-brown discoloration, and the new growth wilted, even following heavy rain. A Dexon drench reduced the disease from 51 percent of the seedlings killed in the check plots to 34 percent in treated plots.

Air Pollution

Weather conditions necessary to bring about natural atmospheric oxidant injury did not occur in western North Carolina in 1962, but considerable information about fluctuations in ground-level oxidant concentrations was obtained. Although potted susceptible grafts were not injured by the relatively low oxidant concentrations, rubber test strips were cracked severely because of relatively high wind speeds combined with these low oxidant levels. Rubber strips are widely used in air pollution work and react by cracking at certain levels of contamination. Susceptible white pines may develop symptoms when exposed to oxidant concentrations as low as 6.5 pphm, but there is no indication that injury is influenced by wind speed.

The highest oxidant concentrations on a mountaintop were found to occur at about 5 a.m. on most days, with levels generally higher at night than during the day. This is in marked contrast to fluctuation patterns found in valleys, where highest oxidant concentrations occurred during the day. During a 3-day check, two recorders operating simultaneously, one on a mountaintop at a 5,000-foot elevation and one in a valley 18 miles distant at a 2,300-foot elevation, showed hourly averages illustrating this same contrast in oxidant fluctuation.

The susceptibility of two white pine clones obtained in West Virginia to industrial stack gases in the Kingston, Tennessee, area was also tested. One clone resistant to injury by naturally occurring oxidant was also found to be resistant to the stack gases present in the exposure area. Another clone susceptible to injury by low oxidant concentrations was severely injured by stack gases. We now believe that trees just as susceptible as the susceptible West Virginia clone grew at one time in the Kingston area, but were killed as air pollution increased in the area and exceeded tolerance levels.



A comparison of hourly averages of oxidant concentrations for two stations at different elevations for July 6, 7, and 8, 1962.

Antibiotic Research

Phytoactin, Acti-dione, and several derivatives of Acti-dione have been applied to seed, seedlings, and plantation-size slash and loblolly pines in attempts to prevent or eradicate infections by the fusiform rust fungus. These treatments neither prevented infection of healthy seedlings nor inhibited sporulation of established infections. Biological assays of treated trees revealed that the antibiotic is rapidly transported from the point of application to foliage tissue, and detectable amounts are present 2 years after treatment; however, this level of the antibiotic in the foliage is ineffective in controlling rust.

The results from studies installed during 1959 and 1960 to determine whether Acti-dione is effective in controlling blister rust on eastern white pine continue to be negative. Treated trees show masking of certain symptoms, such as fruiting; however, there is no question that a majority of the treated cankers are still alive two or more years following treatment. The most favorable results are from a test installed in July 1960, and even in this study three-fourths of the trees have cankers that are obviously still alive and enlarging.

Oak Wilt

During 1962 this Station continued the evaluation of oak wilt control methods in North Carolina and Tennessee. After four years' observations, results show that one-third of the treated plots have had additional trees dying of the disease, as compared to one-half of the nontreated plots. Hence, the control treatment, consisting of felling the trees, spraying the trunks and limbs with an insecticide, and poisoning the stumps, does not eradicate the disease or even reduce it to an acceptably low level.

FOREST MANAGEMENT

The year's progress in forest management research can best be described by summarizing the objectives, programs, and accomplishments of the individual projects. For those not familiar with the Station's make-up, a project is the basic organizational unit of our research planning and conduct. Each project is oriented toward a specific group of problems having something in common. Each involves some special mission of broad regional or national significance and is identified with a broad forest type, a geographic region, subject matter field, or other criteria directly related to the field of investigation. The scope of any project necessarily varies with the complexity of the problems it includes.

The ten forest management projects described here are scattered from Virginia to Florida and each one has from two to six scientists engaged in a program of basic and applied research.

SILVICULTURE OF SHORTLEAF-VIRGINIA PINE

The project scientists are located at Charlottesville, Virginia. Their objective is to develop specific silvicultural practices to reproduce and grow pure and mixed stands of the shortleaf pine-Virginia pine-upland hardwoods types. Emphasis will be placed on finding effective methods of natural regeneration for shortleaf pine, determining the response of Virginia pine to thinning, and developing efficient methods of stand rehabilitation-conversion for the upland hardwoods.

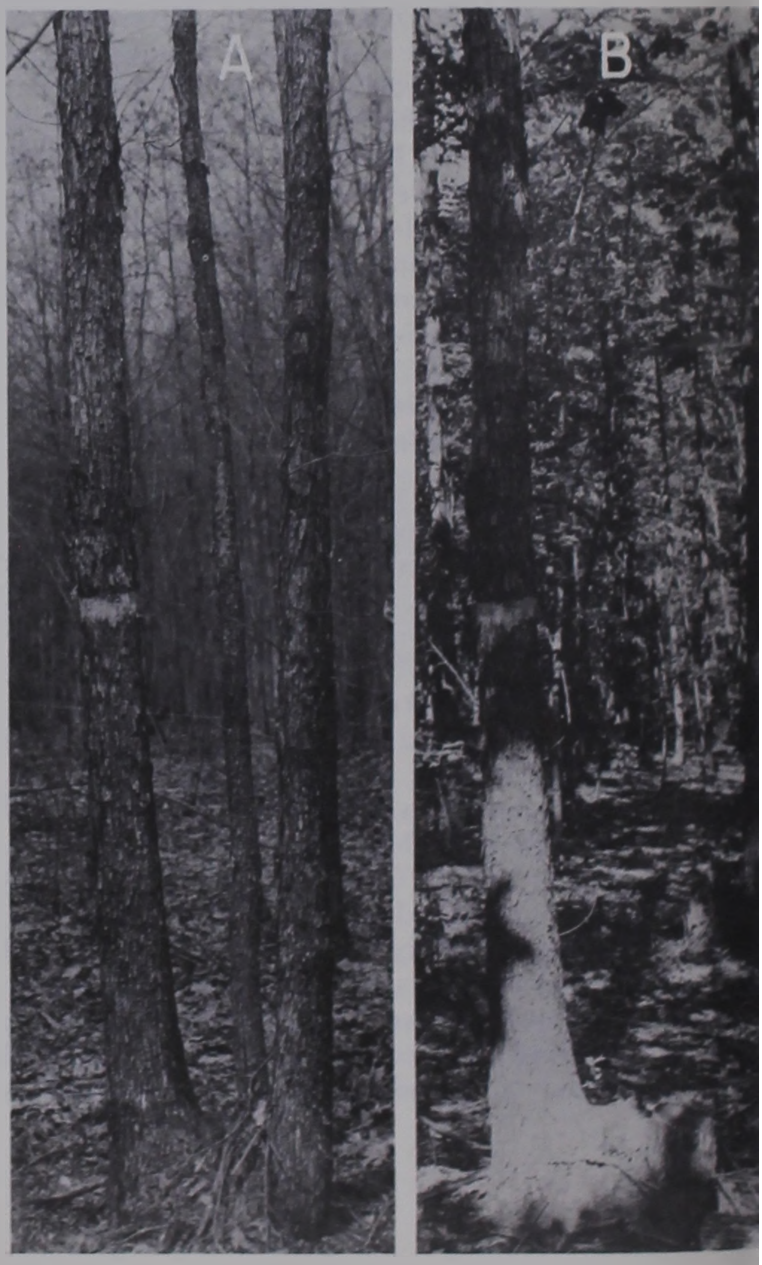
Seedbed Scarification Aids Shortleaf Pine Regeneration

A seedbed scarification study in the North Carolina Piedmont demonstrated the quantitative benefits of scarification on shortleaf pine regeneration. Three 5- to 10-acre stands of sawtimber-sized shortleaf pine were selected in Catawba and Lincoln Counties. Two were well stocked and had never been cut. The third stand had been cutover four years earlier, but had a good stocking of seed trees. Each stand was subdivided into blocks, half of each block being scarified with an 1800-pound disk in October. The other half was left undisturbed.

A good supply of seed, 108 to 159 thousand sound seed per acre, was available at the time the disking was done. Scarification of the seedbed resulted in an adequately stocked stand of reproduction with seven times as many seedlings as on an undisturbed seedbed. The ratio of the number of seed required to establish one seedling was 50:1 for the scarified seedbed and 392:1 for the undisturbed seedbed. Scarification greatly reduced the hardwood competition. After four growing seasons, 54 percent of the scarified area was relatively free of competition.

Scarified seedbed immediately after disking in October.

Scarified seedbed four growing seasons after disking.



(A) White oak sprout clump before the two unmarked sprouts were cut.
(B) The growth of the remaining stem did not equal the growth of all stems in unthinned clumps.

Growth of Thinned White Oak Sprouts

The badly rundown upland hardwood stands in the Virginia-Carolina Piedmont have had little attention in the past except for programs aimed at complete and drastic conversion to pine. Although pine conversion is a shortsighted policy on the better hardwood sites, it is the logical answer on poor sites (site index 50 and lower for oak).

A thinning study was installed in an even-aged 25-year-old stand of pole-size white oak in Virginia. The site index for white oak was 60. One hundred thirty-two sprout clumps were selected. Half of the clumps were treated by cutting all the stems in the clump except the one largest in diameter. The remaining clumps received no cutting, but the crop tree in each clump was selected and marked. The average diameter of the crop trees was slightly over 5 inches at the time of treatment in 1947.

After eleven growing seasons all stems in the unthinned clumps had produced more volume growth than the single remaining stem in the thinned clumps. The loss in cubic-foot growth completely nullified the increased diameter growth of the single stems, because the potential saw-log quality of these sprouts is too low to warrant carrying the oak to sawtimber size.

SILVICULTURE OF SOUTHERN APPALACHIAN HARDWOODS

This project, located at Asheville, North Carolina, is responsible for the Station's program of silvicultural research in the mountains. The objectives are to develop silvicultural practices that will enable Southern Appalachian landowners to reproduce and grow high quality hardwood timber. This will be done by devising methods of intensive culture for the better stands, by timber stand improvement in the cutover stands, by artificial regeneration of the worthless stands, and by improving tree quality through selecting and breeding improved strains of the most valuable species.

Despite the high potential growth capacity of the hardwood forests, the economic pressures of the past have reduced much of the area to a low actual level of productivity. Better methods of forest management must be developed if the forests are to yield sawtimber and pulpwood in quantities that will fill the needs of industry. The current research program includes studies of the natural regeneration of several oak species, the direct seeding of hardwoods, the improvement of the genetic quality of hardwoods, and the growth and yield of yellow-poplar and of white pine.

Yellow-Poplar Site Index Curves

One question forest managers need to have answered is: Does yellow-poplar have the same height-age relations in the Southern Appalachians as it does in the Piedmont? To find out, height-age equations were developed from 267 plots in mountain stands in western North Carolina and northern Georgia and from 117 plots in the Carolina and Virginia Piedmont.

For the Mountains

Logarithm site index =

$$\text{logarithm height} - 9.158\ \left(\frac{1}{50} - \frac{1}{\text{age}}\right).$$

For the Piedmont

Logarithm site index =

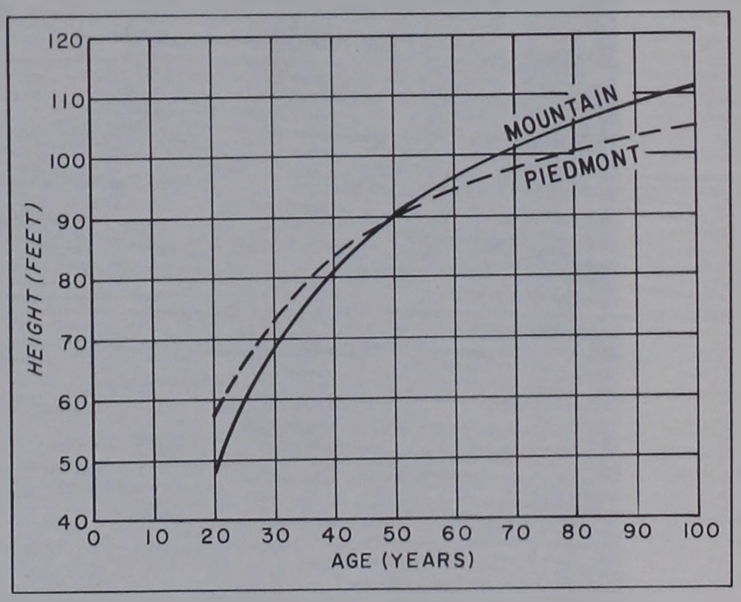
$$\text{logarithm height} - 6.503\ \left(\frac{1}{50} - \frac{1}{\text{age}}\right).$$

The significantly different slope coefficients of the two equations indicate yellow-poplar height-age relations in the mountains do differ from those in the Piedmont. Because of this difference, a single set of curves cannot be used for the two regions.

Accordingly, separate families of site index curves were developed for the two regions. Both sets of curves were compared with McCarthy's U. S. Department of Agriculture Technical Bulletin 356. Only the mountain curves were significantly different. In general, Technical Bulletin 356 underestimates site index in the younger ages and overestimates site index in the older ages when applied to mountain stands.

White Pine Plantation Yields

Although hardwoods dominate the mountain forests, landowners have shown a continuing interest in both natural and planted white pine. White pine has long been the preferred species for planting; from 1952 through 1960 about 20 million seedlings were planted in the 15 western counties of North Carolina.



Yellow-poplar height-age curves for site index 90.

Landowners who invested in white pine plantations are now saying, "I planted these trees 10 years ago. How long will it be before they are big enough to cut?" Others want to know: "In 20 years, what will be the volume per acre in my plantation?"

The answers to these and other related questions are contained in the recently issued Station Paper 149, "Southern Appalachian White Pine Plantations." It contains site index curves, cubic-foot and board-foot volume tables, cubic-foot and board-foot yield tables, cubic-foot to board-foot converting factors, and a table for predicting average stand diameter. This information is presented in easy-to-use tables. A knowledge of tree age, initial spacing, and site index is all that is needed to forecast the future development of white pine plantations.

Biltmore white pine plantation established in 1908 near Asheville, North Carolina. Picture taken 1946.

SILVICULTURE OF SOUTHERN PIEDMONT HARDWOODS

This project is located on the University of Georgia campus in Athens, Georgia, where the project staff has the benefit of the University's facilities and can consult with the forestry faculty. The objectives are to develop the silvicultural principles and improved practices needed to reproduce and grow Piedmont hardwoods. Particular emphasis will be placed on finding successful techniques for planting hardwoods and on determining the best methods of rehabilitating the forests and soils of the littleleaf lands.

Although the present hardwood stands are in poor condition, the number of native hardwood species, the wide range of intra-specific variability, and sensitivity to changes in site conditions are characteristics that provide ample scope for successful silvicultural manipulation.

A great deal must be learned before hardwood planting can be widely recommended as an operationally feasible practice. The major problem is not initial survival but the need for techniques that will aid the planted hardwoods to outgrow the competing vegetation on highly productive hardwood sites. The bottomland sites in Georgia represent a tremendous potential for hardwood growth if we just knew how and where to plant the right species. Promising techniques include site preparation, use of selected planting stock, fertilization, and subsequent care.

Planted Cottonwood on a Prepared Site

Brisk demand for cottonwood pulp to be used in magazine papers and container veneer means that cottonwood is perhaps the most profitable tree to plant on good cottonwood sites. It is a species that needs good soil, adequate moisture, and good site preparation. Complete site preparation — plowing, cross plowing, and disking to level the soil — in a Georgia riverbottom resulted in rapid growth of planted cottonwood. Following two cultivations, the trees grew to an average height of 7 feet the first year. At the end of seven growing seasons the mean height is 48 feet and the average diameter is 5.4 inches. The tallest tree is just over 65 feet and the largest diameter is 9.1 inches.

Cottonwood plantation planted in 1956. Picture taken early in 1962 at the beginning of the seventh growing season.

Although the growth was good, less than half the trees survived. Most of the missing trees were cut by beavers. The survivors were protected by screen wire. A neighboring planting left unprotected was almost completely destroyed by beavers.

Unprotected cottonwood was cut by beaver.

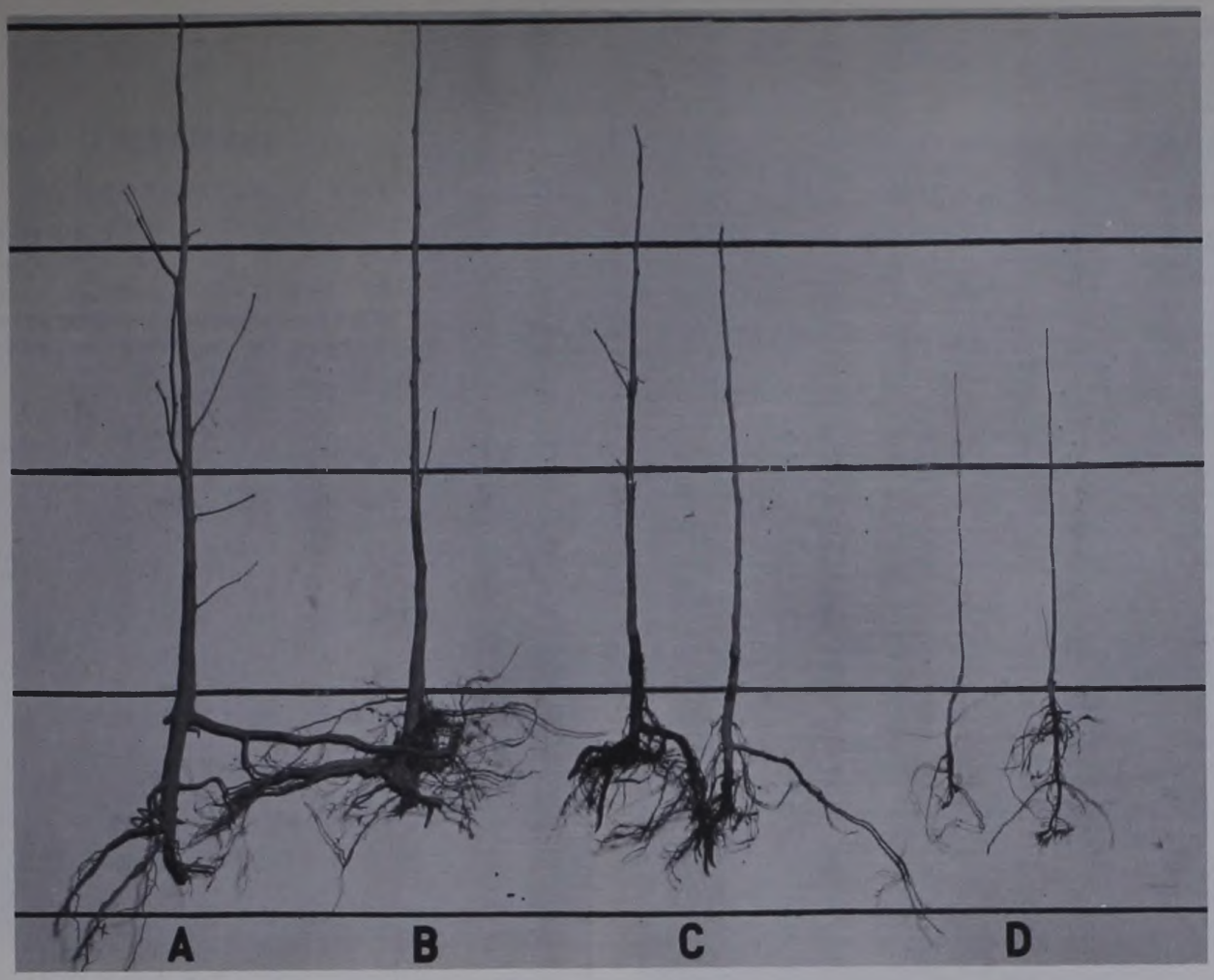
Screen wire shields prevented beaver damage.

Sycamore Planting Stock

Sycamore is a fast-growing bottomland hardwood that is always in demand to supply the furniture industry's needs, but the cut-over natural stands are not regenerating well enough to meet future demand. A sycamore planting on a well-drained bottomland site in the Georgia Piedmont has shown that first-year height growth is related to root collar diameter. Mean height growth ranged from 2.6 feet to 5.9 feet. Bed-run seedlings were sorted into four root-collar diameter classes, three of which were used in this study (less than 0.30 inch, 0.31 to 0.40 inch, and greater than 0.51 inch). For the three classes tested, differences in height growth were statistically significant at the 5-percent probability level (table 3).

Table 3. --Mean total height and first-year height growth of sycamore seedlings

Root collar diameter at planting time (inch)	Mean height at planting time	Mean height at end of growing season	Mean height growth
	- - - - - Feet - - - - -		
Less than 0.30	1.15	3.74	2.59
0.31 to 0.40	1.54	4.54	3.00
Greater than 0.51	1.99	7.89	5.90



Sycamore seedlings arranged by root collar diameter class: (A) large (greater than 0.51 inch); (B) intermediate (0.41 to 0.50 inch); (C) two medium (0.31 to 0.40 inch); and (D) two small (less than 0.30 inch).

Fertilized Sycamore

The value of fertilizer on a good site was tested on 1-year-old sycamore seedlings. A moist but well-drained Piedmont river bottomland site, disked prior to planting, was fertilized with various combinations of nitrogen, phosphorus, and potassium.

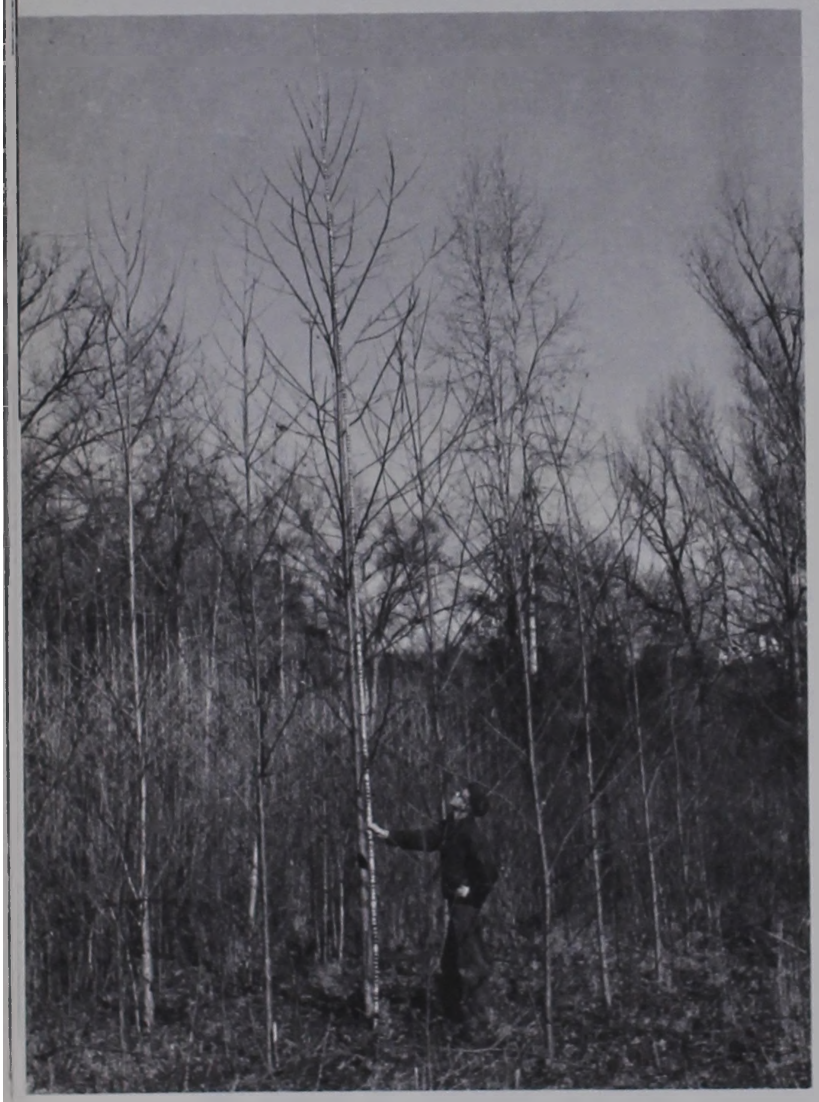
First-year height growth data indicated a strong response to nitrogen fertilizer, a smaller response to phosphorus, and a very slight response to potassium. Unfertilized seedlings grew an average of 3.7 feet the first year, compared with 6.6 feet for those seedlings fertilized at near optimum rates.

Analysis of second-year height growth confirmed the relative importance of nitrogen additions compared to the other two elements. At the end of the second growing season, trees on the best plots averaged 17 feet tall, compared with 10 feet on the untreated check plots. Diameter growth differences corresponding to height growth differences were evident after the second growing season.

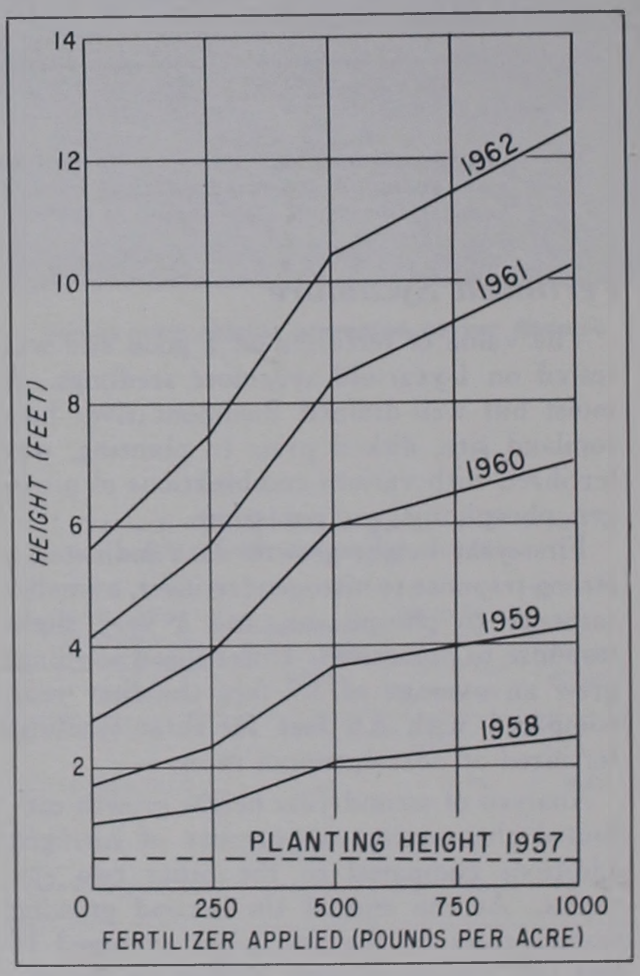
Yellow-Poplar Fertilization

The use of fertilizers at planting time may mean the difference between success or failure of yellow-poplar plantations. In 1956 a planting of yellow-poplar on a streambottom site prepared by disking was treated with four rates of diammonium phosphate (20-52-0). In the 5 years following planting, the more heavily fertilized trees have made excellent growth, while the unfertilized trees are barely keeping up with competing vegetation and naturally seeded sweetgum, boxelder, and water oaks. Fifth-year measurements indicate that the fertilized seedlings are not only maintaining their growth advantage but are actually showing increases in height advantage each year over unfertilized seedlings.

Fertilized sycamore seedlings grew twice as fast as unfertilized seedlings during the first year.



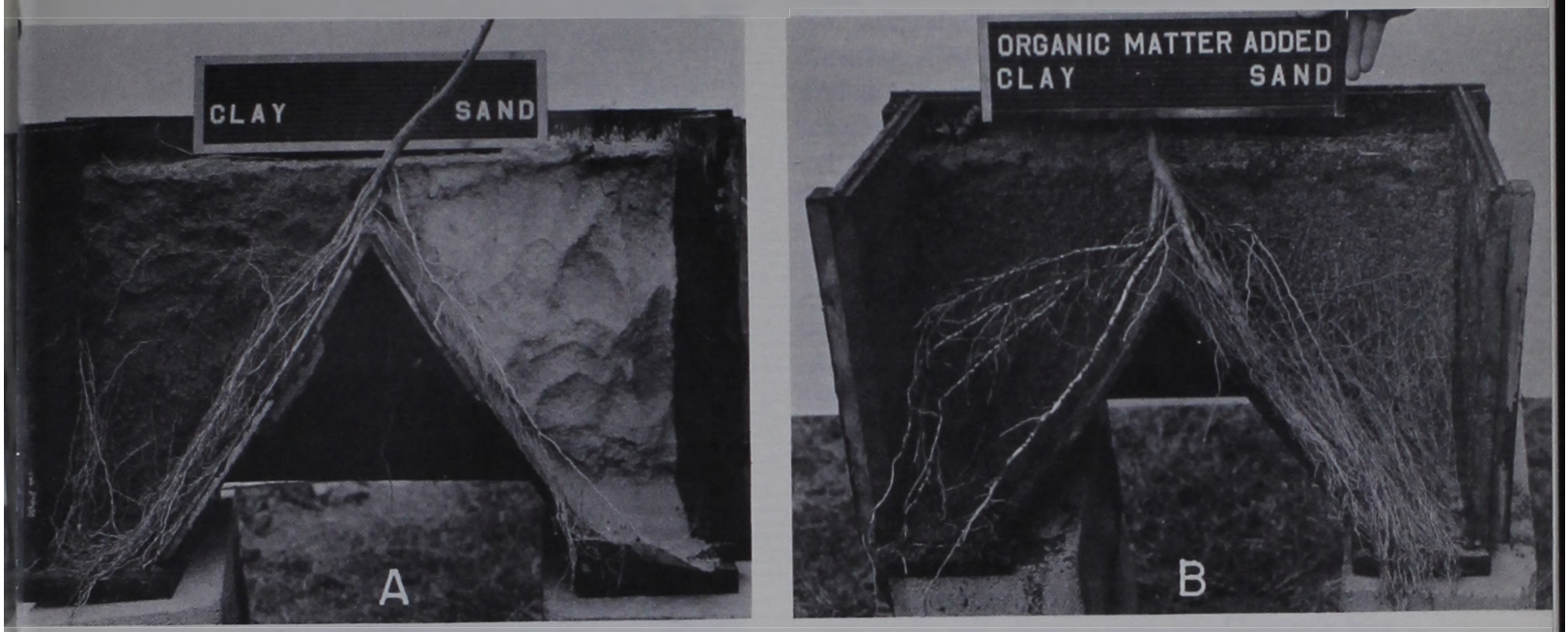
Five-year-old yellow-poplar fertilized with 1,000 pounds per acre of diammonium phosphate (20-52-0).



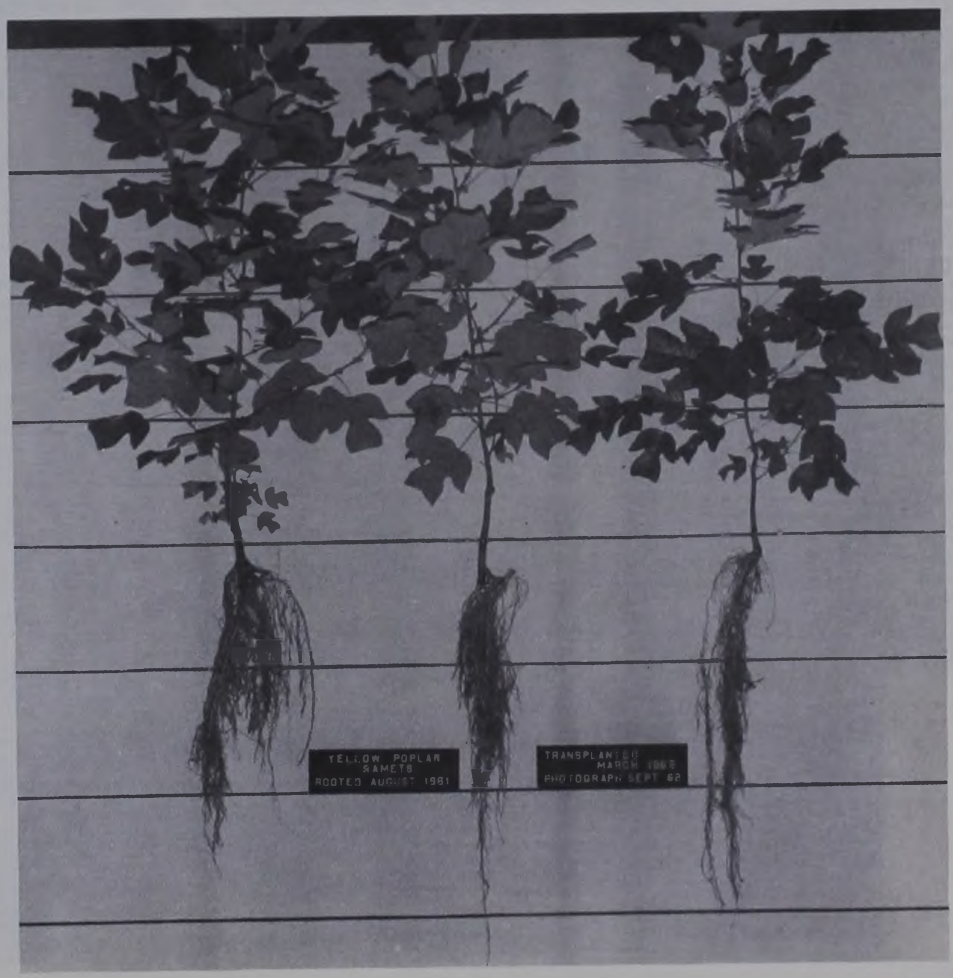
Mean total height of yellow-poplar fertilized with 20-52-0 diammonium phosphate.

New Techniques

An important part of research is the continuing effort to develop new techniques and to adapt old ones to new needs. The split root technique for studies of root development and the use of yellow-poplar stump sprouts for scion stock are examples of techniques research. Successful trials can open up new paths for future research by removing bottlenecks in methodology.



The split root technique is an attempt to measure the effect of soil characteristic on root development. In (A) most of the roots formed in the clay. In (B) the addition of organic matter greatly stimulated root growth in sand.



Yellow-poplar topwood cuttings are difficult to root. Cuttings taken from stump sprouts can be rooted and will survive and grow after being transplanted in the field.

SILVICULTURE OF COASTAL PLAIN TIMBER TYPES

Our project workers, with headquarters at Charleston, South Carolina, and a branch office at Franklin, Virginia, are developing silvicultural principles and practices for intensive management of the coastal plain timber types, including the loblolly pine, the wetland hardwoods, and the Fall Line sandhills types, from increased knowledge of how these types regenerate, grow, and respond to natural or induced changes in their environments. This is an ambitious program but it is in line with the needs of forest managers in the coastal plain.

Loblolly pine silviculture as it is now practiced in the coastal plain is an example of modern forest land management at its best. This high level of management has created a need for even more refined techniques of: regeneration; methods of young stand management; use of fire, chemicals, and mechanical methods of controlling competing vegetation; and assessing the effects of intensively managed pine monoculture on timber yield and site productivity.

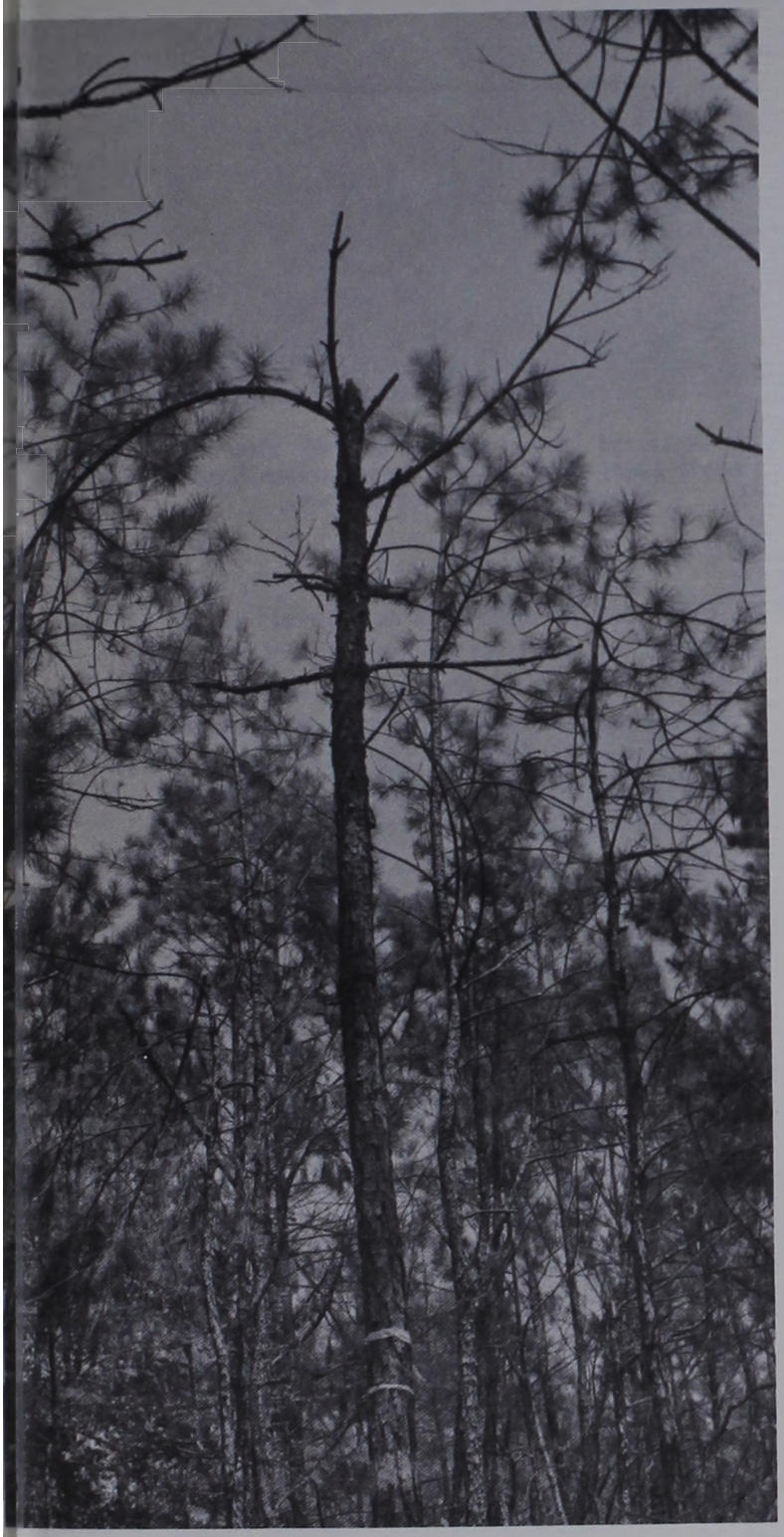
Ice Damage on the Santee

On March 2 and 3 an ice storm struck in a narrow belt across the South Carolina low country. The Santee Experimental Forest, the center of our loblolly pine research in the coastal plain, was one of the areas heavily damaged by the storm. Several long-term research studies suffered considerable damage. Although it was possible to salvage or reinstall the studies, the losses in time and effort were substantial. The work required to salvage the damaged studies made heavy inroads on the planned research program for 1962. More serious is the loss of 1 to 4 years of a planned period of tree or stand response in a damaged study.

Some good will come from this minor catastrophe. We were able to design and install a study that will assess the effects of all degrees of ice damage on the survival and growth of loblolly pine. Within 4 years we will be able to tell land managers how much damage a loblolly pine can sustain and still

A general scene of glaze damage on the Santee Experimental Forest, the result of an ice storm March 2 and 3, 1962.

grow at an acceptable rate. We have already learned that a crash salvage program of all damaged trees can cause a growth loss that is out of proportion to the actual damage.



The tree in the center lost an estimated 94 percent of its crown during the ice storm.

Hurricane Damage

Hurricane Donna, of September 1960, provided the Franklin branch of the project with an equally unwelcome chance to study the effects of disastrous weather.

A survey of 92 natural stands and 10 planted stands, thinned during the preceding 3 years showed that over 99 percent of the damage was uprooting and that stem breakage was negligible.

The preponderance of root damage is explainable by the position of a particular stand in relation to the hurricane's eye and to the rainfall pattern preceding and during the storm. Areas along the coast that are east of the eye usually receive little rainfall and the damage occurs as broken or bent trees. Hurricane Hazel in 1954 produced this type of damage in the study area. Area to the west of eye—such as the study area in Hurricane Donna—usually receives heavy rains, and uprooting is the result.

A large part of the variation in root damage in apparently similar stands was associated with soil characteristics. Damage was higher for soils with a moderately coarse tex-

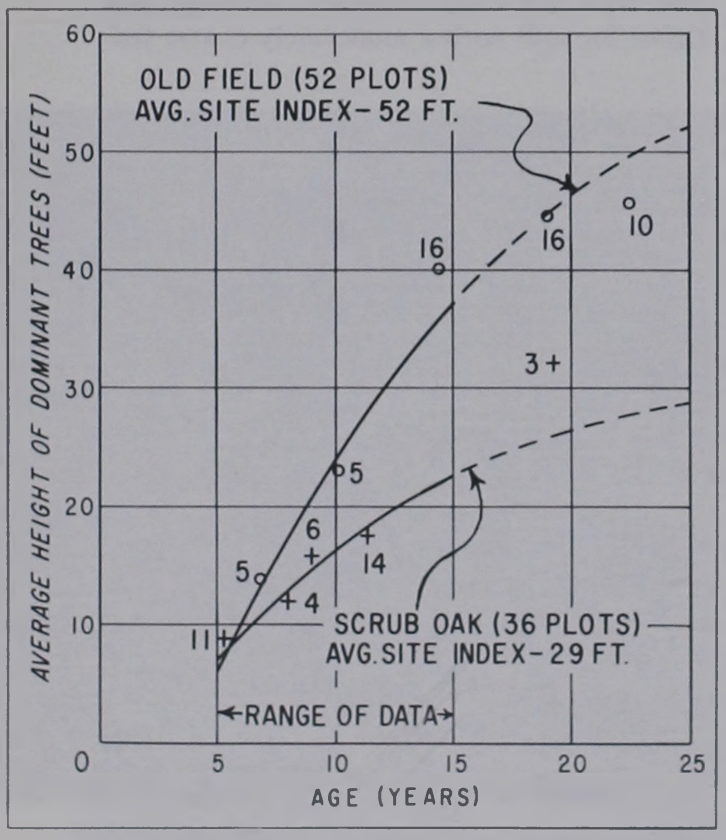
Complete failure of root systems in a small sawtimber stand of loblolly pine on a Norfolk sandy loam soil with an impermeable layer beneath the surface.

ture than for soils with finer textures. The most severe damage occurred on moderately coarse textured soils that were underlain by a less permeable layer within 4 feet of the surface.

Although it would be impractical to vary normal management practices to lessen damage from the occasional hurricane, the soils underlain by impermeable layers should be avoided when especially high-value stands such as seed orchards are being established.

Planting Oak Sites in the Sandhills

Over one-third of the Carolina Sandhills is in coarse deep sands covered with scrub oak. The many successful old-field plantings of slash pine raised hopes that the scrub oak sites would be as productive if cleared and planted to slash pine. Unfortunately this is not entirely true. A recent soil-site study made in cooperation with Duke University School of Forestry shows that the deep sand soils (10 feet or more to a clay layer) of prepared turkey oak sites are considerably poorer than the deep sand soils of old fields.



Average height of dominant trees at various ages for slash pine planted in deep sand on scrub oak and old field sites in the Carolina sandhills.

An excavated stump from a loblolly pine on a Norfolk sandy loam with an impermeable layer 48 inches beneath the surface.

However, plantations on soils with a clay layer within 10 feet of the surface, or on soils with 5- to 8-inch A_1 horizon, attained a height of 63 feet in 25 years. Landowners should use discretion in scrub oak clearing and planting. Lands with a site index of 30 feet at age 25 are submarginal sites. On 40-foot sites the indicated yield at 20 years is about ¼ cord per acre per year. On 50-foot sites, the average for deep sand old-field plantations, yield is 1 cord per acre per year —obviously a much better investment opportunity.

Potentially productive slash pine sites can be selected by examination of soil survey maps and soil profiles of proposed planting areas.

Wetland Forests

Timberland owners and wood-using industries, along with federal and state agencies, have become aware of the value and importance of wetland forests. Nearly 35 percent of the coastal plain is in wetlands. Drainage commands much interest; very large investments have been made and are being planned.

Collecting growth data in a water tupelo swamp in the Santee River Bottoms.

Drainage objectives include timberland accessibility for logging and general management, forest cover-type conversion, and increased timber growth.

There is little quantitative data as to the degree of site improvement and increase in wood production attributable to drainage. Certainly some wetland types will benefit more than others, and in some types drainage may be harmful. However, favorable effects from drainage have been demonstrated on some wetlands, notably pocosins, bays, and wet flats.

Most of our silvicultural work with bottomland hardwoods has been concentrated on the Santee Experimental Forest, near Charleston, South Carolina. Our research involves learning how to manage existing hardwood stands which have reasonably good stocking and species composition, and the replacing of rundown stands by planting and direct seeding.

Preliminary study of selection cutting aimed toward uneven-aged management revealed several possible disadvantages. Logging damage was considerable, water sprouts severely degraded the residual high-quality growing stock, and reproduction did not develop in the openings. Even-aged hardwood management is now being studied through a stand cut to seed trees. All early indications point toward success. Reproduction varies from excellent to adequate throughout the area, and seed-tree losses have been minor, despite two hurricanes and a severe ice storm.

To find means of rehabilitating poor hardwood stands on good sites, a broad variety of the best native species has been planted on creek bottomland and terrace locations. Their performance has been evaluated, and planting recommendations will soon be published.

The research accomplished and currently under way suggests new opportunities and avenues of attack. We want to learn more about the site requirements of individual species, we must determine what the growing conditions are on the numerous wetland types, and we need to know how and to what degree drainage or other measures can improve the site.

SILVICULTURE OF PIEDMONT LOBLOLLY PINE

The silvicultural research on loblolly pine in the coastal plain is matched by loblolly pine research in the Piedmont. Although there are many similarities between the two regions, there are also decided contrasts. In the Piedmont, topography exerts a marked influence on species composition and soil series. Soil types and erosion patterns account for a wide spread of loblolly pine site indexes, ranging from 50 to 110. Loblolly pine seed production in the Piedmont is lower than in the coastal plain. Competition from vines, shrubs, and trees differs, and as a result the management of loblolly pine also varies between the two regions.

In recognition of these regional differences, we have a loblolly research program at Macon, Georgia, to determine the silvicultural principles and practices required to reproduce and grow loblolly pine in the Piedmont that will yield the optimum quantity and quality of commercial products.

Current Research

The relatively low loblolly pine seed production in the Piedmont means that attention must be given to the techniques of natural regeneration. One of the most promising methods to date is the shelterwood method. However, neither the shelterwood method nor any other system is effective if understory hardwoods are allowed to occupy the site. Recent experiments indicate that the smaller hardwoods can be controlled by carefully handled summer fires.

Other studies show that the larger hardwoods, particularly where the fuels will not carry a fire, can be controlled by silvicides applied with a portable mist blower.

The results of these and other studies are also used in comprehensive tests of methods and systems of managing loblolly pine. In the Piedmont, particular attention is given to developing management systems for use on small woodland holdings.

(A) A shelterwood stand of loblolly pine with 6-year-old seedlings.
(B) The same area ten years after the shelterwood had been removed in two operations.

Loblolly pine sawtimber stand with a dense understory of hardwoods.

A summer fire used to control understory hardwoods.

The back pack mist blower is effective on hardwood under 30 feet in height.

SOUTHERN PINE SEED, TREE IMPROVEMENT, AND NURSERY PRACTICES

This project is located at the Georgia Forestry Center near Macon, Georgia, because of its close cooperative ties with the Georgia Forest Research Council, the Georgia Forestry Commission, and the Eastern Tree Seed Laboratory. The objectives of the project scientists are to:

Develop improved techniques for handling tree seed.

Improve storage methods.

Find methods of controlling speed of germination and improving total germination.

Develop improved laboratory techniques for testing tree seeds.

Produce improved strains of the southern pines for use in the climatic area served by this project.

Examine the effects of agronomic practices on nursery production of tree seedlings, with special emphasis on soil amendments, culture, irrigation, and fertility.

The close cooperation of the project with the staff of the Eastern Tree Seed Laboratory is illustrated by some of the seed research completed during the past year.

Pretreatment of Eastern White Pine Seed

The speed of tree seed germination is of concern to all nurserymen. Maximum seed germination in minimum time will reduce the loss to seed predators and produce a more uniform stand of seedlings.

Screening tests conducted by the Eastern Tree Seed Laboratory at Macon, Georgia, showed that forest tree seeds responded in germination to treatment with several organic compounds. Of the compounds screened, citric acid evoked a special interest because of its direct role as a metabolite and possibly as an extractor of growth inhibitors.

The graph shows the response of white pine seeds to the various treatments. The very striking effect of stratification is shown for all treatments. Within each stratification level the time response and the total cumulative percent of germination vary with treatment. These results indicate that citric acid treatment may make it possible to achieve maximum germination in minimum time, thus reducing the risk of seed loss to predators and giving the nurseryman a more uniform stand.

Effect of Hydrogen Peroxide on the Germination of Loblolly and Slash Pine Seed

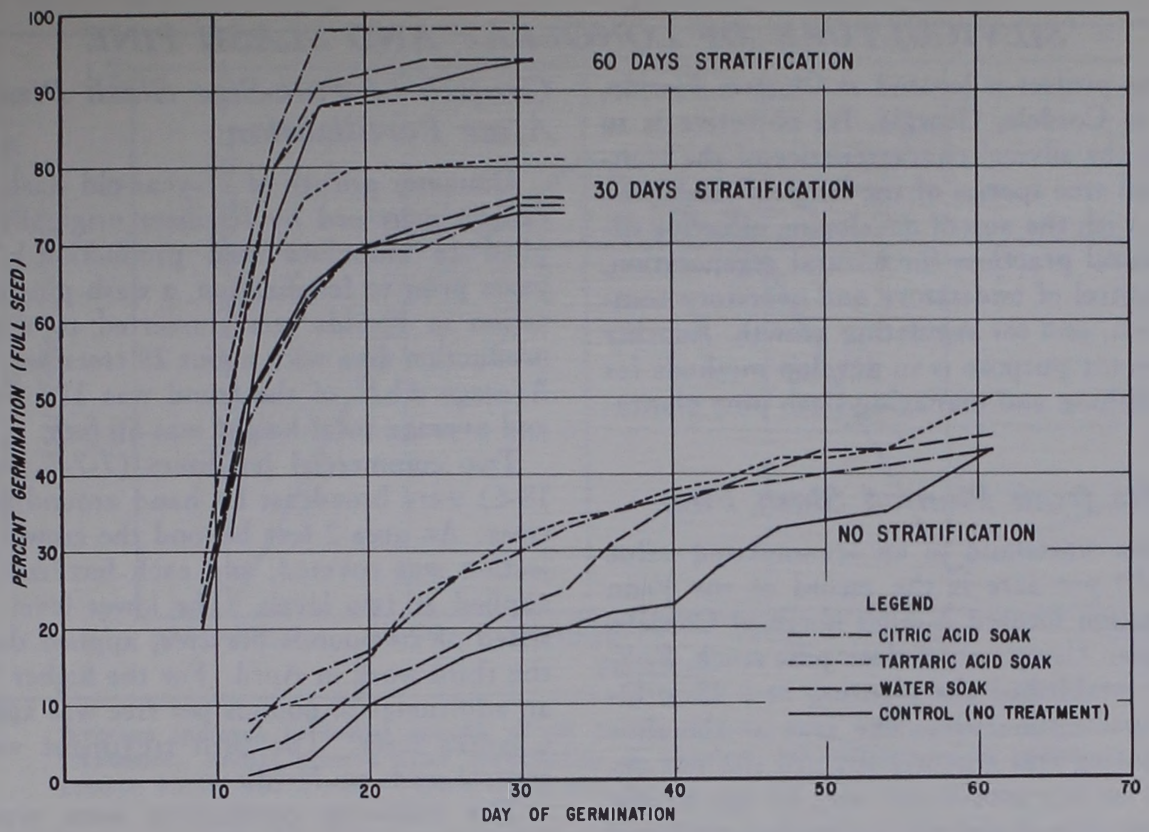
Seed soaked in hydrogen peroxide, seed soaked in water, stratified seed, and untreated or dry seed were compared for speed of germination and total germination.

For a nursery or direct seeding operation, a 1-day soak for slash and a 2- or 3-day soak for loblolly pine in 1-percent hydrogen peroxide should be best. Between 4 and 5 gallons of solution would be needed per pound of seed. The seed should be sowed within a few hours after removal from the hydrogen peroxide solution, and it might be preferable to leave the seed in peroxide for an additional 24 hours if conditions were not suitable for sowing at the end of the original treatment period.

Effect of Methyl Bromide Fumigation on Germination of Southern Pine Seed

The effects of methyl bromide fumigation on longleaf, slash, and loblolly pine seed germination were determined in a study made at the Eastern Tree Seed Laboratory in cooperation with the Plant Quarantine Division, Agricultural Research Service. The seed had moisture contents of 5, 10, and 15 percent; fumigation levels of methyl bromide were 0, 0.5, 1.0, and 2.0 times that normally used to fumigate seed.

Analyses of the data showed a significant difference in germination of longleaf and slash pine seed among moisture content levels within each fumigation treatment level.



Germination of white pine seed following various treatments and stratification periods. Germination counts were taken at 2- to 4-day intervals and percentages calculated on a full-seed basis.

Fumigating at regular dosages did not reduce germination of loblolly pine seed at 5, 10, and 15 percent moisture content. Neither did it damage slash pine at 5 and 10 percent nor longleaf at 5 percent moisture content. Fumigating at twice regular dosage reduced germination of loblolly pine seed at 15 percent moisture content and slash and longleaf at 5, 10, and 15 percent moisture content. This means that both moisture content and dosage level are important in fumigating these and perhaps other tree seed.

Apparently it is safe to apply normal levels of fumigation to longleaf pine seed at 5 percent moisture content and to loblolly and slash pine seed at 5 and 10 percent moisture content.

Forest Tree Breeding

Work continued in Georgia on the applied tree breeding studies. Counts of rust-infected trees in the Georgia Forestry Commission's clonal seed orchards indicated that grafted trees are much more resistant to rust than the general run of slash and loblolly. Sixty percent of the clones had no rust infection, and others had only small amounts. These three seed orchards are in a middle Georgia area of high rust incidence. The orchards, plus other test plantations in middle Georgia, are providing more evidence each year that resistance to rust within slash and loblolly pine species is a strongly inherited trait.

Seed certification assistance was given to states in the South and to interested groups in other regions of the United States in developing programs.

As a service to forest geneticists, forest tree breeders, pulp and paper technologists, silviculturists, and forest managers, a bibliography of forest genetics publications was published in cooperation with the Southern Forest Experiment Station, and, in addition, the monograph by the Technical Association of the Pulp and Paper Industry entitled, "The Influence of Environment and Genetics on Pulpwood Quality, an Annotated Bibliography," was distributed. These two booklets make available results of a vast amount of research that heretofore had been widely scattered throughout the literature.

SILVICULTURE OF LONGLEAF AND SLASH PINE

This project is located at Olustee, Florida, and at Cordele, Georgia. Its objective is to study the silvical characteristics of the commercial tree species of the longleaf-slash pine type, with the aim of developing effective silvicultural practices for natural regeneration, for control of understory and overstory composition, and for regulating growth. Another important purpose is to develop methods for establishing and managing slash pine plantations.

Profits from Planted Slash Pine

From wasteland to an accumulated value of $430 per acre is the record of the Fenn Plantation located 2 miles north of Cordele, Georgia. Using native slash pine stock, F. E. Fenn established the planting at a 12 x 12-foot spacing in 1926. The area at the time of planting was a poorly drained site not devoted to any productive use. At age 33 the average acre of this plantation had produced 9,619 board feet (International ¼-inch rule) of sawtimber, plus 10.6 cords of pulpwood. Harvested products included 3,816 board feet, 4.43 cords, and 9.4 barrels of gum per acre.

How was this unproductive land turned into an asset worth $26,000? It was not because of any particularly good forest management, or unique opportunities. The important decision was made in 1926 when the land was planted to slash pine. Today, notwithstanding the acceptance of the idea that "forestry is good business," there are still many small tracts of agriculturally submarginal land not being used for any gainful purpose. Some of these areas have been idle for only a few years and have not been naturally seeded to any tree species. With the relatively small investment of planting them while they are still open land, the owner can obtain a well-stocked plantation that will be an efficient producer of timber products and have a much higher value in the future.

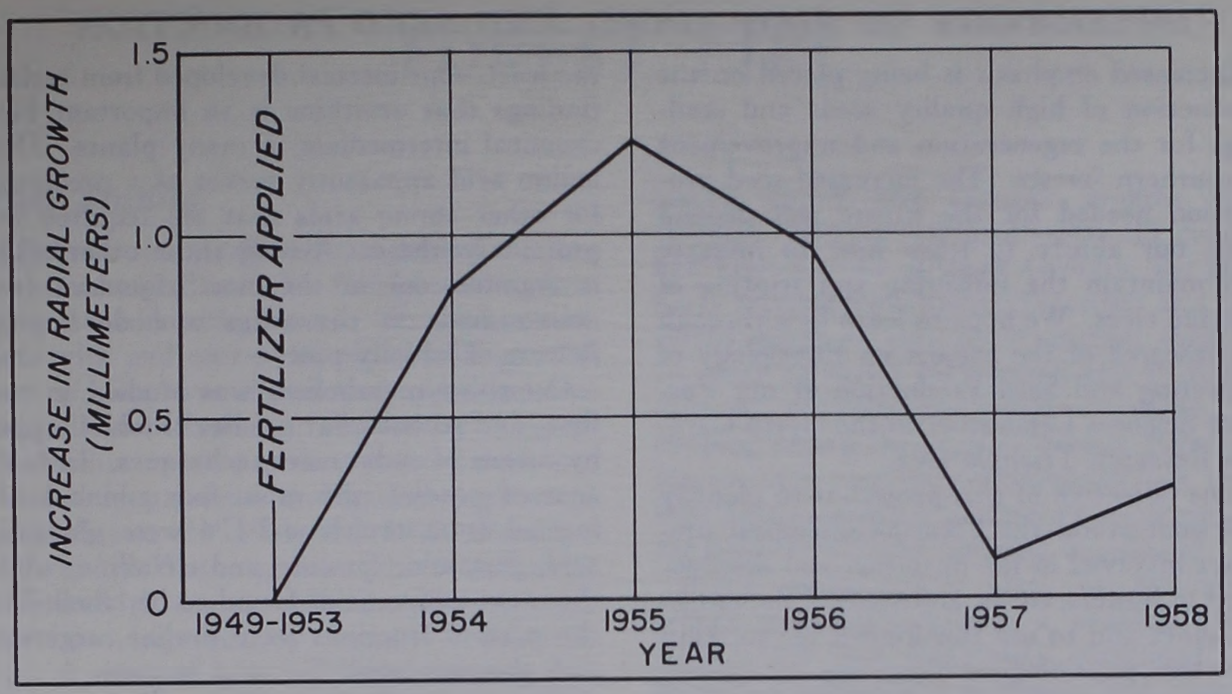
Growth of Pole-Size Slash Pine After Fertilization

Diameter growth of 21-year-old slash pine can be increased by fertilizer originally applied to stimulate seed production. Two years prior to fertilization, a slash pine plantation in Florida was converted to a seed-production area with about 25 trees per acre. Average d.b.h. of the stand was 11.3 inches and average total height was 56 feet.

Two commercial fertilizers (7-7-7 and 3-18-6) were broadcast by hand around single trees. An area 2 feet beyond the crown projection was covered, and each fertilizer was applied at two levels. The lower level consisted of 20 pounds per tree, applied during the third week in April. For the higher level an additional 20 pounds per tree was applied 6 weeks later. The fifth treatment was a control with no fertilizer.

The following conclusions were reached from this study: (1) The average effect of all fertilizer treatments was highly significant in terms of radial growth. (2) The average effect of both levels of 7-7-7 was greater than the average effect of both levels of 3-18-6 fertilizer (highly significant). (3) The average effect of both fertilizers at the 40-pound level was greater than at the 20-pound level (highly significant). (4) An increase from 20 to 40 pounds of 3-18-6 had a greater effect than the same increase of 7-7-7 fertilizer (highly significant).

Growth response by year followed a rather definite trend. Radial growth showed a response to fertilizer during the 3 years following fertilizer application, with a peak during the second year. During the fourth year, radial growth of the fertilized trees dropped to the level of the control trees. There is no reason, as yet, to attach significance to the slight upturn of the response curve during the fifth year after treatment.



Average increase in radial growth of all fertilized trees over control trees after treatment. Radial growth after fertilization is adjusted for differences in radial growth during the 5 years before treatment.

NAVAL STORES PRODUCTION AND TREE IMPROVEMENT

The other research project located at Olustee, Florida, is the Naval Stores Production and Tree Improvement Project. This project has a three-fold objective: (1) To develop extraction techniques, methods, and equipment that will obtain the maximum amount of oleoresin from slash and longleaf pines and allow for integration of naval stores production with the production of timber. (2) To determine the physiological processes involved in the synthesis of oleoresin by slash and longleaf pines. (3) To develop high gum-yielding and otherwise superior strains of slash and longleaf pines.

Although basic research is emphasized, the immediate needs of landowners and naval stores operators are not neglected, and a series of applied research studies is producing results that can be put to use.

Naval Stores Production in Louisiana

In 1919-1920 the State of Louisiana produced about 18 percent of the U. S. output of gum rosin. Approximately 10 million faces were worked during this season. Logging, uncontrolled annual burning, and destructive extraction methods soon devastated the virgin forests of longleaf (yellow) pine. Gum production as a profitable business gradually ceased entirely.

In 1961 a gum-yield study was established in southwestern Louisiana to analyze the factors which influence gum flow in slash pine plantations. To stimulate good yields for the relatively short producing season in Louisiana, streaks 1 inch in height of bark depth were chipped and treated with 60-percent sulfuric acid at consistent 14-day intervals. The first regular streak of the producing season was applied on April 10, 1961, and the concluding streak on November 2, giving a total of 16 for the season. Gum yield from the planted slash pine sampled in this test was in sufficient volume to warrant organized production on a commercial scale. The total yield of 259 barrels per crop compares favorably with yields from slash pine of similar size and quality growing in other sections of the naval stores belt. The study trees averaged 11.5 inches d.b.h., with 30 percent live crown. They yielded gum at an average rate of 1.6 barrels per streak per 1,000 faces.

PHYSIOLOGY OF FLOWERING AND SEED PRODUCTION

Increased emphasis is being placed on the production of high quality seeds and seedlings for the regeneration and improvement of southern forests. The increased seed production needed for the future will depend upon our ability to learn how to increase and maintain the flowering and fruiting of selected trees. We hope to learn how through the research of the project on Physiology of Flowering and Seed Production at our Forestry Sciences Laboratory in the North Carolina Research Triangle area.

The objective of this project is to identify and understand the basic physiological processes involved in the initiation and development of flowers, cones, and seeds of the southern pines and to use this knowledge to regulate the physiological processes to control flower, cone, and seed production. A great deal of basic physiological research is needed before much can be done on the practical problem of seed production.

Ornithine-2-C^{14} Metabolism in Loblolly Pine Needles

At first glance the connection between ornithine metabolism and seed production in loblolly pine appears to be tenuous to say the least. Our interest developed from earlier findings that ornithine is an important biochemical intermediate in many plants. This amino acid apparently serves as a precursor for other amino acids that are required for protein synthesis. Among these other acids is arginine, one of the most abundant free amino acids in the twigs and developing flowers of loblolly pine.

Ornithine metabolism was studied in the first- and second-year needles of loblolly pine by means of radiotracer techniques. In both ages of needles, the main free amino acids formed from ornithine-2-C^{14} were glutamic acid, glutamine, proline, and citrulline; while the main amino acids found to be labelled in the protein fractions were proline, arginine, and glutamic acid.

This one study in itself does little toward solving the practical problem of increasing loblolly pine seed production, but it has given us another bit of knowledge that will be fitted into place in the physiological puzzle of the flowering processes of loblolly pine.

SOIL-TREE RELATIONS

The Soil-Tree Relations project, also located at the Forestry Sciences Laboratory, is staffed by two soil scientists who are studying the effects of species composition, silvicultural practices, and land-use alternatives on the physical, chemical, and biological properties of forest soils. Much of the past forest soils research has been confined to practical forest management problems, such as estimating site index from soil properties, studying the effects of fertilizer on tree growth, and determining the effects of fire on erosion. Valuable as this work has been, more basic information is needed before real progress can be made in solving the many soil problems facing foresters today.

Decomposition of Litter

Progress in basic research is the process of moving from question to question. During the past year we have attempted to learn something about the meso-faunal populations (mites, springtails, and other small arthropods) of the litter of several tree species, and the role of these meso-fauna in litter decomposition. Anything we learn will be but one link in the long chain of unknowns concerning the reduction of the forest floor. Our specific interest in the current study is the role of certain classes of mites in litter decomposition.

FOREST FIRE

Fuel Studies

Palmetto and gallberry are two of the major sources of flammable fuel in southeastern coastal plain pine forests. They also compete with and crowd out pine seedlings. Recent studies have shown that summer burning or winter burning followed by a repeat fire within two years has reduced fuel, but the kill of palmetto and gallberry plants is insignificant. In 1961 and 1962, investigations on the Waycross State Forest in Georgia indicated that a combination fire-herbicide operation significantly increased palmetto kill. A spray of 2, 4, 5-T in August at a rate of 2 pounds per acre ($3.00 for chemical) following a prescribed winter fire killed 30 percent of the palmetto plants. This treatment was more than twice as effective as the use of herbicide without fire.

While fire will consume foliage and stems of these plants, a winter fire will not usually kill them, and they grow rapidly in the following spring and summer months. For example, one year after 15-year-old roughs had been burned in south Georgia, the gallberry regrowth was about 70 percent and palmetto about 55 percent of original weights. In order to better understand this regrowth process, we defoliated specimen plants by clipping during the growing season. Palmetto regrew at a rate only moderately less than that before clipping; gallberry's regrowth, on the other hand, was retarded drastically.

Even when aerial parts of individual plants were burned with a propane torch (2700° F.) and completely consumed, regrowth of palmetto was prompt and prolific, and no mortality was observed. We now believe that repeated crown defoliation and accompanying physiological reactions, rather than heat, are probably responsible for the death of palmetto plants exposed to repeat burning.

Combination fire-herbicide treatments are retarding palmetto growth and often result in crown kill.

Fire Control

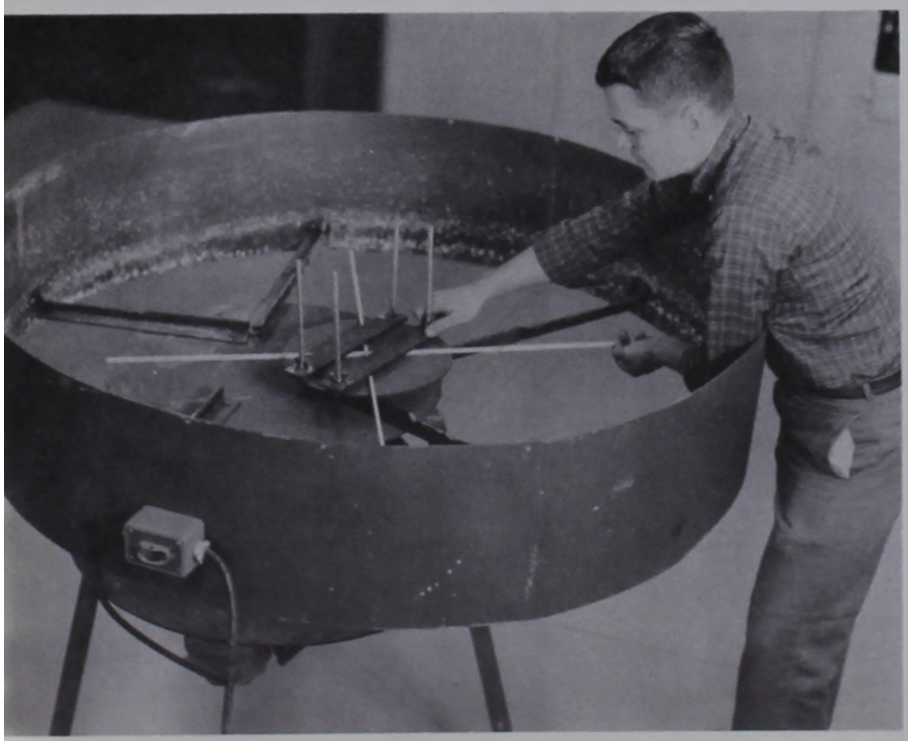
Ammonium phosphate solutions are being used extensively in the southeastern section of the country for wildfire control. In cooperation with chemical and clay companies, Macon laboratory workers have shown that diammonium phosphate (DAP) solutions can be successfully thickened by several industrial gums or hydrating clays. These thickened retardant mixtures are superior to unthickened mixtures because they have greater adhesion and retention, and can be aerially dropped from higher altitudes without loss of delivery concentration on forest fuels. Also, dyes added to thickened retardants impart color to vegetation. This last advantage is important in showing tanker pilots where previous drops have been made. Unthickened phosphate solutions, even with dyes added, generally do not transmit the dye color to vegetative fuels.

Sodium alginate, carboxymethyl cellulose, and guar gum were effective thickeners at concentrations of 1 percent or less. Clay thickeners cost only one-tenth as much, although somewhat more clay was required for the same viscosities.

Ammonium phosphate is a plant fertilizer, whereas sodium calcium borate, another good fire retardant used extensively in the West, is known to be a mild soil sterilant toxic to vegetation. On a clear-cut area in south Georgia, where both these retardants were evaluated at application rates of 1 to 3 gallons per 100 square feet, slash pine seedlings were planted following two diskings of the area. After two growing seasons, seedlings on the area treated with ammonium phosphate were 50 percent taller than the others. Disking and leaching had apparently dispersed the borate to the extent that no toxic effects remained, since seedlings planted in the borate area compared favorably with those in the check zone with regard to survival and height growth.

Fire Effects

During the past year, the initial stages of work with bark properties were reported in a Ph.D. thesis by Robert E. Martin (University of Michigan). Thermal conductivity of bark in several species of pine and hardwood was shown to vary with density, moisture content, and temperature. The same relationship is found applicable for wood, but the thermal conductivity of wood is greater than that for bark of the same density. Specific heat and its elevation due to absorbed moisture were nearly the same for both bark and wood. The thermal diffusivity of bark (ratio of conductivity to volumetric specific heat) was found to be almost constant for wide ranges of density, moisture content, and temperature. This discovery may simplify the solution to the heat-flow problem and consequently increase our understanding of fire effects on tree stems.

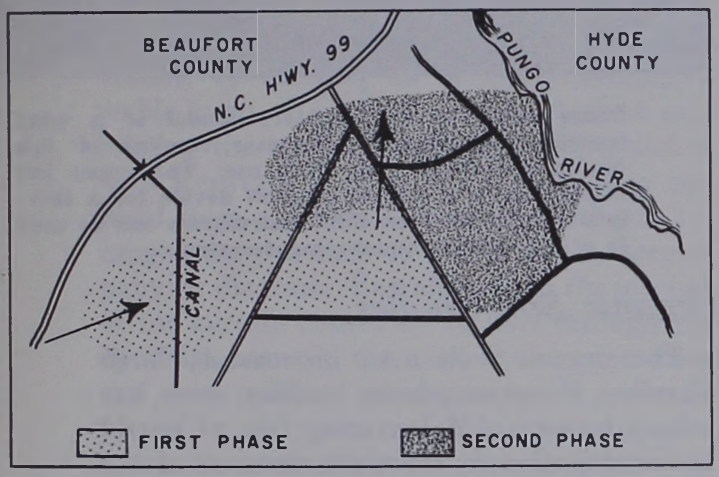


Adhesive and retentive capabilities of retardant mixtures are evaluated by spinning treated sticks in a centrifuge and measuring the amount of material remaining.

Pantego 1962 Wildfire

Documentation of wildfires provides records that can be studied in depth, and this accumulated information is helping researchers to identify factors leading to blowup fires.

During the Pantego fire of May 6, 1962, in eastern North Carolina, approximately 1,500 acres were lost during 5 hours of "normal burning." Changing conditions late in the day caused the fire to blow up, and in 45 minutes more acres were lost than during the preceding 5 hours.



The Pantego 1962 wildfire, showing first and second phases.

The wildfire started at 1:30 p.m. on May 6, 1962, when control of a brush-burning operation was lost. During its first phase, the fire was driven by a moderate west northwest wind and traveled 4 miles through heavy, dry underbrush (fuel rating of 7 to 10 tons per acre). White, billowy, fire-caused cumulus clouds were observed at the top of the long smoke plume extending ahead of the main fire front. Numerous small whirlwinds traveled through the fire, picking up embers and burning material, dropping them over the control lines. Spot fires occurred north and east of the fire for a distance of 1/8 to 1/4 mile. By 6:40 p.m., an estimated 1,500 acres had burned.

At 6:40 p.m., the wind backed suddenly to the south southwest and then picked up to 10 or 12 m.p.h., turning much of the north flank into a head fire; a huge convection column developed within 10 minutes as the head moved into extremely dry logging slash (fuel rating 16 tons per acre). The fire reached blowup proportions and spread rapidly to the Pungo River. This burning period lasted about 45 minutes, during which the fire traveled 1½ miles. Indraft wind speeds within 800 feet of the blowup were reported as 40 to 50 m.p.h., and burning materials the size of pencils were carried into the convection column. Flashes of flame extended to 500 feet in the column. Where there was an overstory, the fire ran through the tree crowns, with flames shooting to 100 feet above the canopy. At 7:20 p.m., when it reached an old burn and a hardwood swamp bordering the Pungo River, the forward spread of fire was halted and the fire brought under control.

The dominant features leading to blowup were the sharp windshift that changed the long north flank to a head fire, and the increased fuel available in the logged-over area. During the blowup period the material consumed per hour and the heat output of the fire increased tenfold, and acreage burned per hour increased five times.

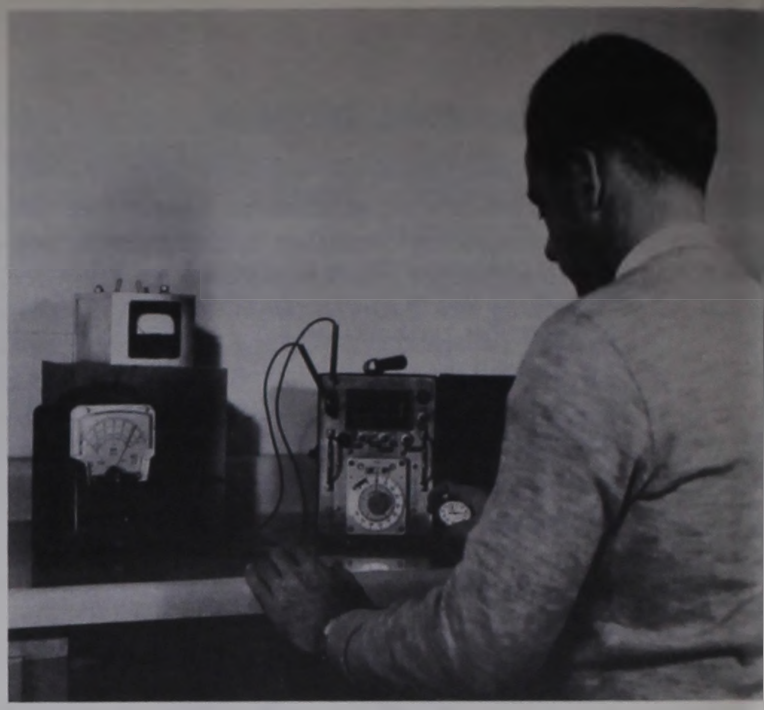
Weather Forecasting and Research

Analysis of Georgia's annual fire danger statistics in terms of actual fire experience has led to increased application of fire weather forecasts to forest operation and fire control planning. More fires occurred in Georgia in 1961, a very dry year, than in either of the previous 2 years. Reducing the statistics to a common danger base (acres burned per 1,000 units of burning index per million acres protected), we found that 18.5 percent fewer acres burned in 1961 than might have been expected. Debris burning, smoking, and incendiarism were again the statewide leaders in fire causes. Hunters were reported as important contributors only in the mountainous north districts.

The National Fire Danger Rating System

Field testing of phase I of the preliminary national system, which started late in 1961, was extended to all Regions in 1962. In cooperation with Region 8 and state forestry organizations, laboratory personnel have installed 12 test stations in 6 states. At year's end about 70 selected fire weather stations were cooperating in the test program. In addition to their regular duties at a standard fire danger station, observers computed fine fuel moisture, buildup index, relative dryness, and spread index for the national system. These computations are based on daily measurements of wet and dry bulb temperature, 24-hour precipitation, and wind speed. Revised tables incorporating a few corrections and an improved format following 6 months' field experience were distributed in October.

Observer reads the wet and dry bulb thermometer on the "mortar board" psychrometer. This laboratory-developed device is rugged, easy to read, and accurate. Over 20 stations in the East are using this instrument in connection with the field testing program of the National Fire Danger Rating System.



Bench checking a laboratory model of a wind recording instrument. Compact versions of this device may have wide field use. The upper left instrument is a remote readout device for a thermistor psychrometer. Both instruments can be used in a fire danger measurement system.

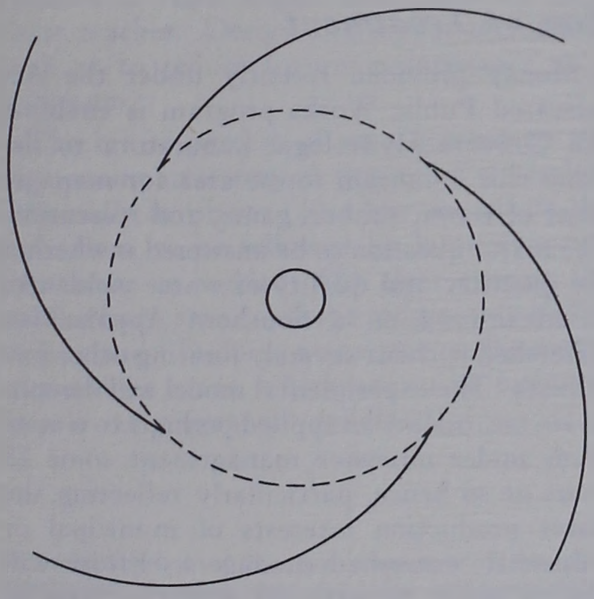
Organic Soil Studies

The organic soils area in coastal North Carolina, comprising some 2 million acres, has a long history of devastating fires. Control at times is almost impossible because of the generally large amount of understory vegetation, poor trafficability, and because the soil itself will burn when dry. As a step toward solving the extremely difficult fire problem, studies were made of weights and moisture contents of understory fuels. Both of these variables strongly influence fire behavior. Results from most of the research done on organic soils in eastern North Carolina have been published. The Station Paper, "Seasonal Moisture Fluctuations in Four Species of Pocosin Vegetation," relates seasonal and daily changes in moisture content of cyrilla, reeds, gallberry, and redbay to weather and soil variables. Whole plant moisture content changes slow even with a continuous fall in the water table.

In the Station Paper, "Forest Fuels on Organic and Associated Soils in the Coastal Plain of North Carolina," a theoretical energy basis is used to classify the fuels by their weight per acre, and blowup fire potential is rated.

Convection Research

Many behavior characteristics of large fires are due to convection processes resulting from the energy released by burning fuel. One of the most violent of the convection patterns is the fire whirlwind. Continued studies of these whirlwinds have given a better understanding of their structure and the conditions causing them. Using the concept of a generating eddy and aerodynamic sink, fire whirlwinds have been produced in the open air. Generating eddies (symmetrical volumes of air slowly rotating about a vertical axis) are readily produced in enclosed cylindrical shells. In the open air, production has been more difficult, since an unenclosed volume of rotating air is not ordinarily a stable type of motion. One method of stabilizing the open air eddy is to surround it with a curtain of air which flows rapidly upward from a series of closely spaced jets arranged on arcs such as shown in the accompanying diagram. Entrainment in the interior of the curtain causes air to flow through the openings between the arcs, thus maintaining the slow rotation in the eddy. If a fire is placed in the center of the system of arcs (also the center of the eddy), a fire whirlwind will result. Another way of stabilizing the eddy is to replace the arcs of air jets with arcs of flame.



A curtain of air flowing rapidly upward is formed by a large number of closely spaced air jets located on arcs about a central heat source. Arcs of flame may be substituted for the arcs of air jets.

Fire whirlwind in the open air formed by the air-curtain method. Whirl is about 7 feet in height. Turbulent structure of whirl is probably due to irregular crib.

Fire Models

Research on free-burning fires on a laboratory scale continued during the past year.

Radiative heat energy from fifteen crib fires tested was approximately one-fifth of the total energy released.

Measurements on fifty test fires showed that convective heat represents about two-thirds of the total energy released.

Average emissivities (radio of radiant energy emitted by a surface to that emitted by a "black body" at the same temperature) for thirty fires tested were 0.18 for the rear view and 0.32 for the side view. "Rear view" and "side view" arise from consideration of a geometrical view factor. The difference between these values is due to the greater depth of flames when viewed from the side. Emissivity of flames has application in calculating radiative heat transfer to unburned fuels.

Cubical wood cribs burned in a special chamber under cyclonic (fire whirl) burning conditions revealed that rate of combustion was about 1½ times the rate of similar cribs burned under natural airflow.

WATERSHED MANAGEMENT

PILOT TESTING MULTIPLE USE ON A SMALL MOUNTAIN WATERSHED

For some time the Southeastern Station has felt the need to establish a small working model of applied multiple use management. As used here, multiple use assumes that value return from all forest uses could exceed that from any single use, and that most forest land can be used for a variety of purposes without undue conflict. A corollary assumption is that each acre of forest land is probably better suited to some use or uses than to others and that many considerations may control management priorities.

We believed that the compatibility or conflict of uses and the intricate relationships between site, forest, and use as observed on a pilot test basis could yield much useful information. It would also serve as a demonstration of one kind of multiple use management.

Of particular interest is the application of the multiple use concept to the high water-yielding forests of the mountain areas of north Georgia, western North Carolina, eastern Tennessee, and southwestern Virginia. Watershed 28, a 350-acre unit on the Coweeta Experimental Forest, is representative of much of the higher-elevation country in the Southern Appalachians and offers an excellent opportunity for study. Although steep and rocky in places, the more accessible areas were high graded for logs, acid bark, and ties from 1900 to 1925, and since early times the whole area was burned regularly to clear the understory for grazing. The original stand was predominantly chestnut, subsequently killed by blight. On the moist, deep soils of the coves (132 acres), fast-growing stands of yellow-poplar have developed, but with a high percentage of older wolf and cull trees. The intermediate ridges (145 acres) have remnants of the old stand and much young growth but generally lack quality trees. The higher rocky ridges (83 acres), supporting much laurel and rhododendron, never were logged but have a low growth potential.

As for water and other resources, the pilot watershed is one of the highest water-yielding areas in eastern North America. Rainfall averages 90 inches annually and there are 6½ miles of streams with a mean annual flow sufficient to supply the needs of a modern community of a thousand people. About a half mile of stream carries native brook trout; and deer, squirrel, turkey, and grouse are heavily hunted during open seasons. The upper rim of the watershed gets much recreation use, for immediately to the west is the Standing Indian Wildlife Management Area, drawing hunters from all over the Southeast. Also, the Appalachian Trail follows the ridgetop where there are weekend hikers and picnickers during all seasons. Into the watershed itself few people venture, since the area is inaccessible and unproductive in its present state.

Plan of Treatment

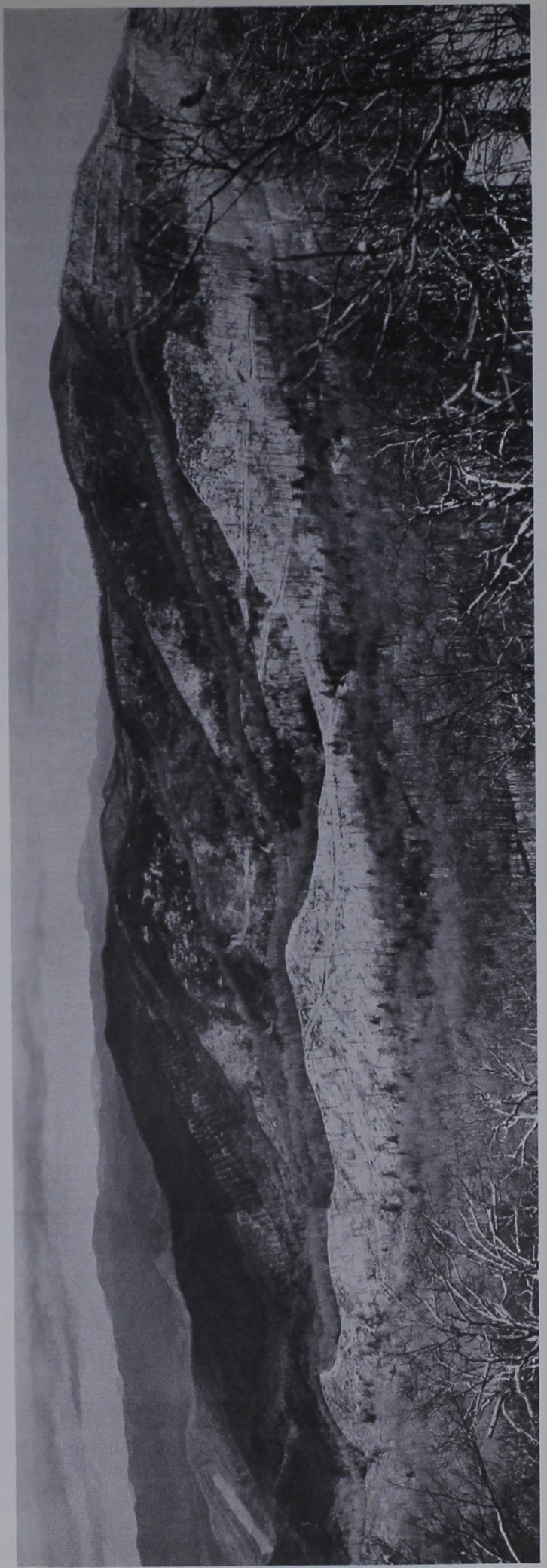
Money provided recently under the Accelerated Public Works program is enabling the Coweeta Hydrologic Laboratory to develop this mountain forest area for management of water, timber, game, and recreation. The major question to be answered is whether the quantity and quality of water yields can be maximized on a Southern Appalachian watershed without severely limiting other forest uses. The experimental model will demonstrate treatments as applied perhaps to watersheds under intensive management some 25 years or so hence, particularly reflecting the water production interests of municipal or industrial watershed managers. Effort will also be made to serve all potential users of the forest and to harmonize their requirements.

Naturally, some basic principles must be defined at the start. One is the thesis that water is the key resource against which to measure and regulate total use of these well-watered mountain lands. Hence, practices to increase or harvest other resources have to be tailored to effects on quantity and quality of water yield, since, it is reasoned, no practice damaging to water supply can fail in the long run to damage total productivity of the unit.

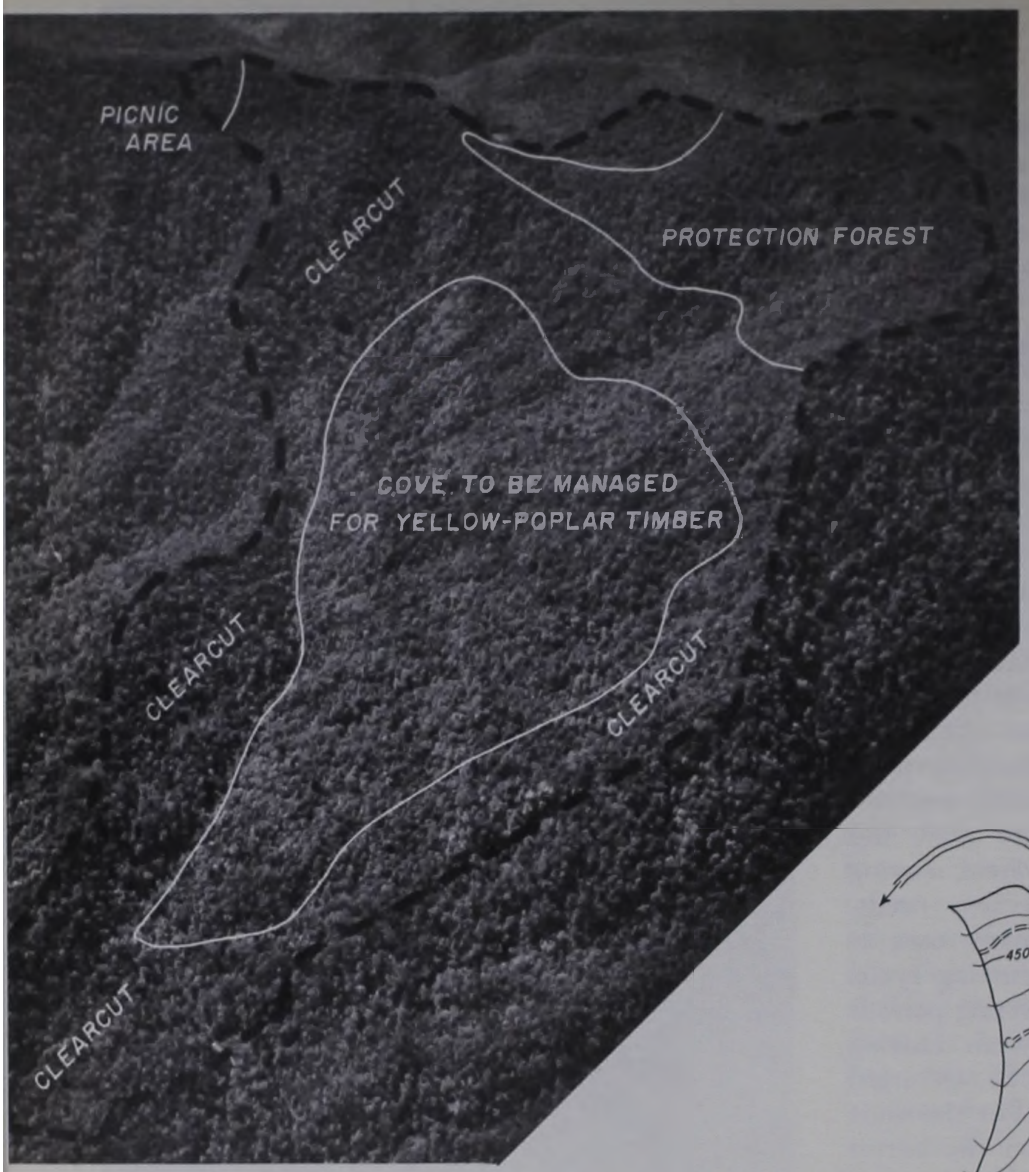
Roads Are the Key

Another basic premise is that road access is the key, for after all if people can't get in or products can't be taken out, little management is possible. Logging roads have traditionally been built as one-shot operations to extract stumpage without regard for serving other forest uses, present or future. Accordingly, the first step was to plan and construct a permanent road system serving all foreseeable uses and protection needs, costs to be amortized by as many uses as feasible over the first 80-year cutting cycle. Timber harvest will require recurring periods of maximum access, but between cutting cycles portions of the system can be converted to wildlife plantings and trails. For the most part, the climb hauls will be on the better classes of roads, with access to work areas mainly from contour roads which cross streams at right angles and climb for only short reaches. Design and layout of roads is such as to reduce future maintenance to a minimum.

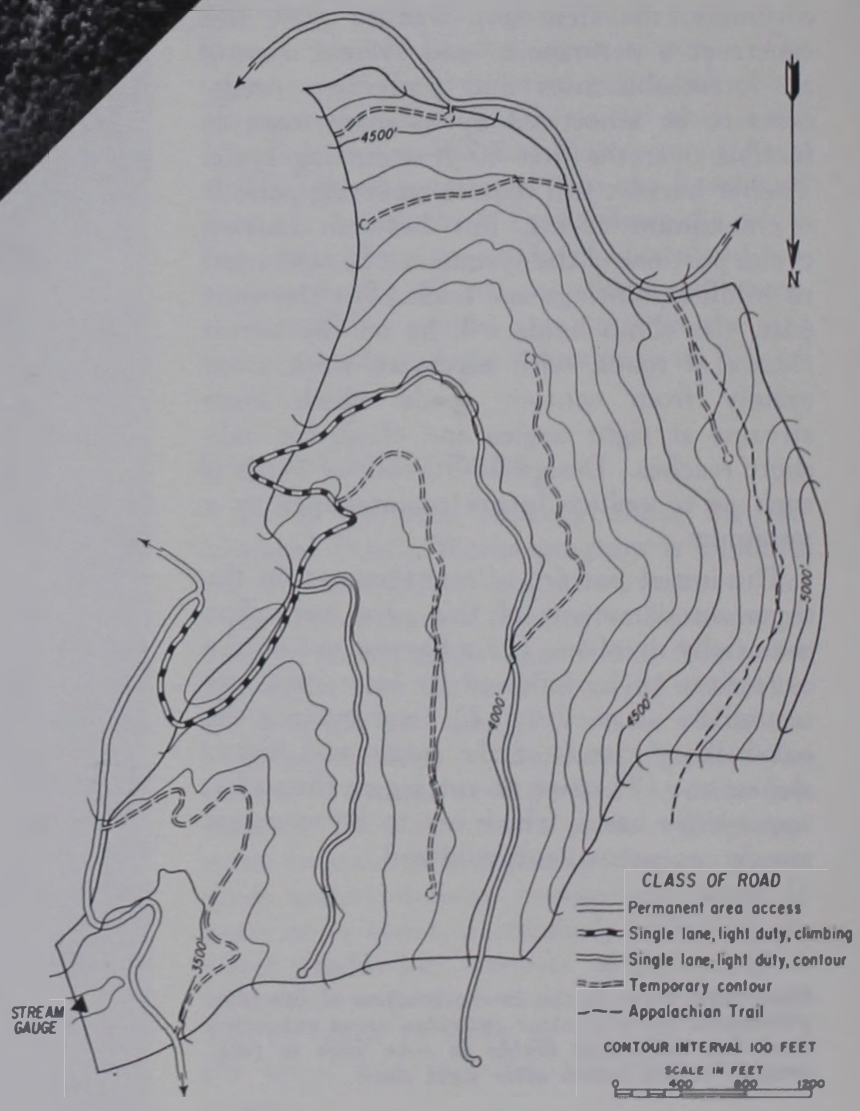
The initial pattern of management on the three compartments of this pilot watershed essentially involves: (1) a harvest cut on the cove sites, to be followed by later improvement cuts as needed; (2) clear cutting the oak-hickory stands of the ridges and higher slopes; and (3) doing no cutting on the rocky, upper-slope areas, which are to be managed mostly as permanent wildland.



Panoramic view of the lower reaches of the pilot watershed, showing clear-cut ridge areas extending from the watershed divide to cove sites in foreground. Photo taken after light snow.



Management compartments, pilot watershed.



Permanent road system for multiple use management.

Properly constructed road dip at stream crossing.

Broad-based dips formed by bulldozers to direct overland flow from long road slopes.

Improving Water Yield

A major objective is to increase quantity of water while holding quality at a very high level. Expectations here are backed by a quarter century of Coweeta research which shows that careful timber cutting and harvesting can increase water yields without damage to quality; and that the first-year increases will be roughly proportional to the percentage of basal area cut. Expected initial water yield increases of about 9 inches will, of course, diminish as stands recover after cuttings, but can be regained to some extent by further cutting treatment. Most of the followup cutting will be in the cove sites, where a 10- to 15-year timber harvest should maintain water yields well above pretreatment levels. Other possibilities include subsequent thinnings on the clear-cut ridge areas, repeated clear cutting where reproduction proves to be of poor quality, recutting the cove understory, and converting to brush stands on portions of the high ridges.

Lower stream reach improved by clearing, debris removal, and water impoundment.

Timber, Recreation, and Wildlife

Although there has been much discussion as to the best methods of upgrading oak-hickory stands in the Southern Appalachians, recent research indicates that clear cutting may afford the best means of regenerating the poorer stands and putting them ultimately into manageable, productive condition. The young tulip poplar stands of the cove sites will respond well to management and provide most of the timber revenue during the early years. The upper ridges, where there has been virtually no increase in basal area in the past 20 years, can be written off for timber production but will serve in maintaining good watershed conditions.

Roads have been kept as far from streams as possible, crossing them at right angles over properly selected culverts. Broad-base dips are being installed in lieu of straight grades and smooth roadbeds. These water-spreading and diverting structures should require very little future maintenance since they have been built up to heights that truck wheels cannot obliterate. Portions of the road system not needed between timber cutting cycles will be seeded to grasses and forbs for wildlife cover and forage and to control erosion.

There is an estimated half million board feet of merchantable oak, poplar, hemlock, and hickory on the pilot watershed. Salable material will be winched up to contour roads and loaded for truck hauling only when the road system is reasonably dry and firm. Damaged or cull trees will be felled and logged as harvesting proceeds. Density of the road system should make this a practical operation although there may be some delays during seasons when trafficability is marginal.

Improving game habitat is a cardinal aim in this test. Cutting operations will greatly increase and diversify browse production and provide more openings for understory food plants. Forage supplies will be augmented by roadbed plantings, and the roads will afford access for adequate harvest of game during hunting seasons. Although streams large enough to support native brook trout are limited, stream improvement should improve the fish harvest. Along the lower stream reaches, thick brush is being cleared and the channel cleaned of debris from early logging. Low log dams have been installed at intervals to provide larger pools for the fish. Timber cutting will open up sections of the stream to sunlight, thus favoring growth of bottom fauna and other food. On the other hand, thick brush cover and debris will be retained upstream to discourage fishermen from too drastically reducing the fish population.

Recreational use imposes special requirements. A picnic area, scenic vistas, and an attractive trail to the fire tower will be the main features. Water may have to be piped to these areas which, in view of the need to protect stream channels from excessive trampling, must be located at a safe distance upslope. Road gates and signs will be relied on to hold visitors along the upper edge of the watershed well above streams and high-value timber.

This pilot test is sure to prompt much discussion and, hopefully, some controversy. Its intent is not to set the standards for managing similar land units but to afford visual aid and a workshop demonstration of effective multiple use of a forested watershed in the Appalachian mountains. Cost of treatments is high by present standards, but there can be little doubt that the unit is being put in much better shape for management for each of the major uses.

FOREST INSECTS

Elm Spanworm

The continued epidemic of the elm spanworm with its defoliation of hardwoods in almost 2 million acres of the southern Appalachians, and particularly its movement into Joyce Kilmer National Monument and the Great Smoky Mountains, has intensified need for improved control measures. Presently, DDT is being used only on restricted high-value areas. Sixteen new insecticides and five pathogens were studied in cooperation with the Entomology Department of the University of Georgia to determine their effects on elm spanworm larvae. Particular attention was given to recently developed carbamate and organic phosphate compounds of low vertebrate toxicity and to improved formulations of the pathogen, *Bacillus thuringiensis*. A virus isolated from native populations of elm spanworm larvae and a gypsy moth virus were also evaluated.

Zectran, a methyl carbamate, proved promising against the spanworm at a concentration of 0.01 percent; *B. thuringiensis* was effective at concentrations ranging from 0.08 to 0.4 percent. A few other insecticides approached Zectran in effectiveness. The viruses caused mortality but were not outstanding in their effects. On the basis of these results, plans will be made to study more intensely *B. thuringiensis* and Zectran in laboratory and small-scale field studies.

Balsam Woolly Aphid

The balsam woolly aphid continued to kill Fraser fir trees in the Mt. Mitchell area in 1962. It is estimated that approximately 275,000 trees have been killed within this 7,500-acre scenic area since the outbreak was detected in 1957. Since 1959 studies have been in progress to evaluate foreign insect predators for their effectiveness in controlling the aphid. To date 18 species have been released in the infested stands. Four predators from Germany are showing promise of becoming established: the Derodontid beetle, *Laricobius erichsonii;* two ladybird beetles, *Pullus impexus* and *Aphidecta obliterata;* and a small midge, *Aphidoletes thompsoni.* Other species have been introduced from Australia, India, and Pakistan (table 4). The most promising of these, *L. erichsonii,* was studied in a pilot test this year. Twelve thousand beetles were released during May at 13 points approximately one mile apart. Some releases were made in cages, others were free releases. The behavior at release points was observed for several months. Observations will be continued annually to determine the degree of success of the releases.

Initially our studies were directed toward discovery of an outstanding species of predator, one which would establish itself and successfully control the aphid. Now, however, we feel that there is much greater chance for success in a complex of several species that would provide a continuous, ever-feeding community of aphid enemies and exert enough pressure to reduce the aphid population below tree-killing level. Thus the life history, behavior, and population dynamics of native predators, as well as the introduced, are being studied.

Southern Pine Beetle

One of the most destructive epidemics of the southern pine beetle to hit the pine forests of the Southeast in recent years prevails in the Upper Piedmont of Georgia, South Carolina, and North Carolina. Well over one million trees were killed in these States during 1962.

During such epidemics, as well as during endemic periods, it is frequently necessary to know population trends and the factors which appear to influence these trends. An essential part of getting this information is that of making brood counts. In the case of the southern pine beetle, this poses a problem. Unlike other southern bark beetles, this species goes through its developmental stages in the soft inner and adjacent outer bark, rather than at the bark-wood interface. Brood

Table 4. --Foreign insect predators released for control of the balsam woolly aphid in North Carolina, 1959-1962

Species	Origin	Released	Released
		Number	Year
Coleoptera			
Coccinellidae			
Pullus impexus	Germany	290	1960
Aphidecta obliterata	Germany	1,200	1960
Scymnus pumilia	Australia	1,900	1960
Harmonia breiti	India, Pakistan	131	1961
Ballia dianae	India	205	1961
Ballia eucharis	India	74	1961
Calvia sp.	India	55	1961
Adonia variegata	India	15	1961
Adalia tetraspilota	Pakistan	65	1961
Oenopia sauzeti	India	90	1961
Diptera			
Cecidomyiidae			
Aphidoletes thompsoni	Germany	8,809	1959
Chamaemyiidae			
Leucopis obscura	Northeast. U. S.	1,508	1960, 1962
Leucopis griseola	Germany	126	1961
Syrphidae			
Metasyrphus lunulatus	Germany	50	1961
Neuroptera			
Chrysopidae			
Chrysopa sp.	India	569	1961
Chrysopa sp.	India	76	1962
Hemerobiidae			
Hemerobius sp.	India	47	1961, 1962
Coleoptera			
Derodontidae			
Laricobius erichsonii	Germany	14,006	1959, 1960, 1962
Total		29,211	

counts can only be made by the tedious and time-consuming process of bark sample dissection. To speed up sampling methods, we explored the possibilities of X-ray.

Radiographs were taken of 3- by 6-inch shortleaf pine bark samples containing southern pine beetle broods, and maps of each sample were made that indicated the position and stage of each insect on the radiograph. The samples were then dissected to determine the congruity of insects recorded on radiographs and actually dissected from samples.

Results of the study were highly satisfactory; during the time required to make a single brood count by dissection, 18 counts were made by X-ray. Furthermore, the X-ray count was found to be as accurate as dissection. The X-ray method has other advantages as well; the radiographs may be readily marked off to compare the efficiency of bark samples of different sizes and shapes, and further sampling studies may be carried out at any convenient time and is not restricted to time when living insects are in the bark.

Further study is planned to determine the smallest sample size which will yield accurate figures and to improve the quality of the radiographs.

Pine Tip Moths

Systemic insecticides may be the answer to the need for cheaper, easier-to-apply, and more effective control for tip moths in forest nurseries. Systemics are taken up by the plant and kill only those insects that feed on the plant's tissue. In order to study the effects of granular systemic insecticides, an experimental nursery was built at our Macon field station in cooperation with the Georgia Forest Research Council and the Georgia Forestry Commission. Each 40-foot bed was divided into ten 4- by 4-foot plots by placing wooden dividers in the bed. This layout made it possible to evaluate various dosage levels with several replications of each treatment.

First-year results indicate that a single application of certain granular insecticides to the soil prior to planting virtually eliminated tip moth attack for the entire season. If subsequent experiments confirm these findings, we expect to have a granular insecticide that will: (1) Reduce the number of treatments from several to one; (2) Eliminate the difficult timing problem encountered with sprays; and (3) Reduce labor cost since it can be applied at the same time beds are prepared.

Oleoresin Crystallization Study

During studies of the biology of tip moths at Macon in 1960, a phenomenon was observed which may explain differences in susceptibility of pines to attack. It was noted that differing rates of pine oleoresin crystallization occurred among the four southern pines when attacked by members of the genus *Rhyacionia*. Rapid crystallization of the exuding oleoresin occurred when growing shoots of shortleaf and loblolly pines were fed upon; however, when longleaf and slash pines were attacked, the oleoresin remained quite viscous. This suggested that absence of injury to longleaf pine and infrequent injury to slash pine might be related to oleoresin composition and its physical characteristics.

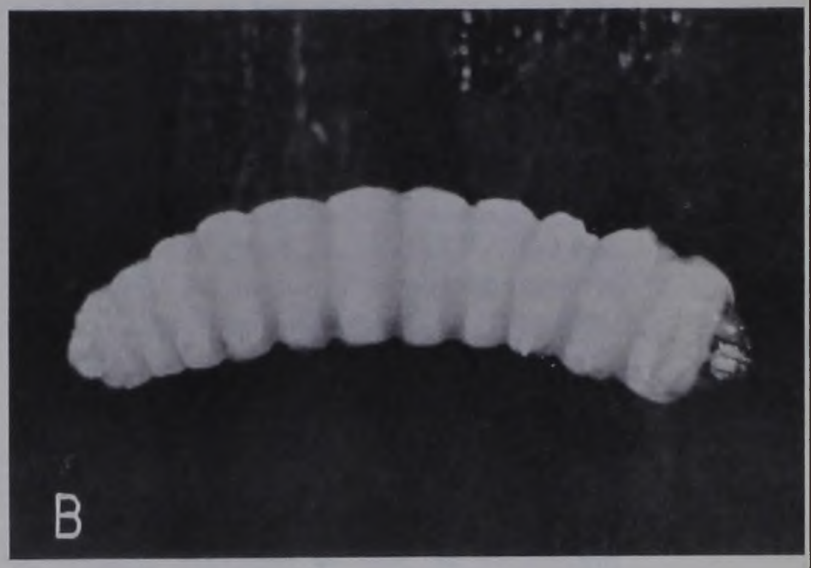
This phenomenon is now being intensively studied in an attempt to explain how larvae are able to accelerate oleoresin crystallization and why certain oleoresins are affected and others are not. Such knowledge may ultimately lead to new avenues of insect control. Research thus far has failed to show that the physiology of the larvae is related to crystallization.

This experimental nursery was constructed in 1962 to test the effect of various granular systemic insecticide soil treatments on pine tip moth infestations.

A loblolly pine shoot attacked and injured by tip moth. In this species of pine, as with shortleaf pine, the exuding resin rapidly becomes crystalline.

Insects Affecting Seed Production

Tree-planting rates in the South have rocketed over the past three decades. The area now leads the nation in plantation establishment. During 1960 over a half-million acres were planted to pine in the States of Georgia and Florida alone. Such planting has increased the demand for seed high in quality as well as quantity. This demand has led to the establishment of seed-production areas and seed orchards of selected trees. In order to attain the desired seed yield from these areas, seed losses must be reduced. One of the primary causes of such losses is insect damage.



The moth (A), mature larva (B), and overwintering galleries (C), of Laspeyresia anaranjada Miller. The larva or seedworm of this species destroys only the seeds within the second-year or maturing cones of pine. It has been found to destroy about 10 percent of the total viable slash pine seed crop in north Florida.

In 1956 a three-phase research program was started in northern Florida to study such insect damage to flowers, cones, and seed of slash, *Pinus elliottii* Engelm., and longleaf, *Pinus palustris* Mill., pines. The first phase was the identification of the insects and of their injury; the second to study their biologies; and the third to develop means for their control.

During the past year the first phase was completed. Over the years cones and shoots have been collected and examined for damage. A habitat list was made of the insects found in slash and longleaf pine material; a key to insect-caused damage to flowers, seeds, and cones was devised; and an annotated list of insects was written. All this material, with an accompanying text, has now been assembled for publication.

Substantial progress has also been made in research toward achieving a control treatment, particularly one that is useful in seed orchards. Greater emphasis is now being given to devising treatments which will control insects in seed-producing areas.

Considerable knowledge on the biology of the primary insects has been gathered in the course of the investigations. However, much more needs to be learned about their behavior and ecology in order that the best possible control measures may be devised: preventive as well as remedial, natural as well as chemical.

In view of losses found in slash pine seed production, it became quite apparent that a survey of insect damage to loblolly pine was needed. This year an exploratory study was made in the Piedmont and upper coastal plain of Georgia.

Mature cones were collected from 12 separate loblolly pine stands throughout middle Georgia. Over 3,000 cones were cut open and more than 14,000 seeds were examined to determine if insects or insect damage were present.

Infestation of coneworms, *Dioryctria* spp., was found in 18 percent of the cones sampled in 7 coastal plain counties, and 14 percent from 5 Piedmont counties. Seedworms, *Laspeyresia* spp., destroyed 2 percent of the seed from coastal plain counties and 4 percent from Piedmont counties.

It is readily apparent from the results of this exploratory work that insects cause a substantial loss of loblolly seed. This points up a need for further study to determine more precisely the full impact of the damage; i.e., the degree of attack on flowers and immature cones and the species of insects involved. Ultimately the life history and habits of primary species must be learned and control methods developed. Knowledge gained from research on insects affecting slash pine seed production will be applied insofar as possible.

Insect Research at the Forestry Sciences Laboratory

A milestone in forest insect research was laid with the opening this year of the Forestry Sciences Laboratory in the North Carolina Research Triangle. Basic research in two long-neglected fields was begun. A project was set up in physiology and biochemistry with emphasis on nutrition and genetics. A second project, on biological control, will include research in insect pathology and parasitic and predatory insects. The objectives of the program are to unravel some of the complex phenomena in the biology of forest insects and ultimately discover highly effective natural control methods as well as improved chemical methods.

PUBLICATIONS
by
MEMBERS OF THE STAFF
INCLUDING COOPERATORS
Calendar Year 1962

ADAMS, H. E., and SCHOCH, M. S.
1961 forest fires and fire danger in Connecticut, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia.
(Twelve separate reports containing tables and graphs analyzing forest fires and fire danger.)

ALLEN, P. H.
Black willow dominates baldcypress-tupelo swamp eight years after clear cutting. Southeast. Forest Expt. Sta. Res. Notes 177, 2 pp.
(After fall and winter high-load logging, the new stand was dominated by black willow.)

ALLEN, R. M., and McGREGOR, W. H. D.
Seedling growth of three southern pine species under long and short days. Silvae Genetica 11, Heft 2:43-45.
(Shortleaf pine seedlings grew similar to loblolly pine under short days, but under long days showed differences. Longleaf pine seedlings showed no differences attributable to geographic source.)

AMMAN, G. D.
Seasonal biology of the balsam woolly aphid on Mt. Mitchell, North Carolina. Jour. Econ. Ent. 55: 96-98, illus.
(Observations of aphid development were made at about 14-day intervals. Some aphids completed three generations, but most completed only two.)

BARBER, J. C.
Tree seed certification programs and needs of Georgia. Ann. Meet. West. Reforestation Coordinating Com. Proc. 1961: 7-10.
(A description of the program and benefits expected.)

BARNES, R. L.
Formation of γ-guanidinobutyric acid in pine tissues. Nature 193(4817): 781.
(A large amount of arginine is converted to γ-guanidinobutyric acid in pine tissues.)

BARNES, R. L.
Glutamine synthesis and translocation in pine. Plant Physiol. 37(3): 323-326, illus.
(Glutamic acid served as a precursor of glutamine in isolated roots of pond pine and in loblolly pine seedlings, apparently via the glutamine synthetase reaction.)

BARNES, R. L.
Ornithine-2-C^{14} metabolism in loblolly pine needles. Forest Sci. 8:284-287.
(The main free amino acids formed from ornithine-2-C^{14} were glutamic acid, glutamine, proline, and citrulline; the main amino acids found to be labeled in the protein fractions were proline, arginine, and glutamic acid.)

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BARNES, R. L., and NAYLOR, A. W.
Formation of β-alanine by pine tissues supplied with intermediates in uracil and orotic acid metabolism. Plant Physiol. 37(2):171-175.
(Pyrimidine catabolism is an important mechanism of β-alanine synthesis in the pine tissues examined.)

BECK, D. E.
Yellow-poplar site index curves. Southeast. Forest Expt. Sta. Res. Notes 180, 2 pp.
(Separate site index curves are shown for the Southern Appalachian Mountains and the Virginia-Carolina Piedmont.)

BENGTSON, G. W., and VOIGT, G. K.
A greenhouse study of relations between nutrient movement and conversion in a sandy soil and the nutrition of slash pine seedlings. Soil Sci. Soc. Amer. Proc. 26(6): 609-612.
(Virtually all NH_4NO_3 and KCl applied to the soil surface was leached from the upper 12 inches of the profile. Fertilized seedlings transpired from 30 to 80 percent more water than controls, yet their water use per gram of dry matter produced was 25 to 50 percent less.)

BERRY, C. R., and RIPPERTON, L. A.
Ozone, a possible cause of white pine emergence tipburn. (Abs.) Phytopathology 52(8):724.
(Emergence tipburn was observed in the field following recorded ozone concentrations as high as 6:5 pphm. Similar symptoms were produced on greenhouse plants using artificially produced ozone at the same levels.)

BOIS, P. J., FLICK, R. A., and GILMER, W. D.
A study of outside storage of hardwood pulp chips in the Southeast. TAPPI 45(8):609-618, illus.
(Oak and gum pulp chips stored in the open for 6 months were measured for specific gravity, moisture content, fungus attack, and effect of chip deterioration on pulp quality.)

BOIS, P. J., and WHITE, J. F.
Wood-using industries in Georgia—a utilization report and directory. Coop. Pub. Ga. Forestry Comn. and U. S. Forest Serv. Southeast. Forest Expt. Sta., 142 pp., illus.
(A county by county wood-industry directory combined with a detailed wood-industry production report.)

BOYCE, J. S., Jr.
Fomes annosus in white pine in North Carolina. Jour. Forestry 60:553-557, illus.
(Annosus root rot causes butt rot, killing, or windthrow of white pines in natural and planted stands, ranging from 22 to 100 years in age.)

BOYCE, J. S., Jr.
Greenhouse inoculations of coniferous seedlings with Fomes annosus. (Abs.) Phytopathology 52(1):4.
(A relatively low percentage of infection resulted from inoculating five species of pines with *Fomes annosus*.)

BRENDER, E. V., and McCOMB, W. H.
Farming the woods. Ga. Forest Res. Paper 12, 4 pp., illus.
(A case study of a 29-acre woodlot in piedmont Georgia in which 1 acre is clear cut and planted each year.)

BRYAN, M. B., and McCLURE, J. P.
Board-foot and cubic-foot volume computing equations for Southeastern tree species. Southeast. Forest Expt. Sta. Paper 145, 10 pp., illus.
(Diameter inside bark at top of saw-log portion of tree is used in addition to d.b.h., cordwood length, and saw-log length to improve accuracy of volume predicting equations.)

BRYAN, W. C., and ZAK, BRATISLAV
Additional syntheses of mycorrhizae on shortleaf and loblolly pines. Forest Sci. 8:384.
(An extension of the list of Hymenomycetes which have been found to form mycorrhizae on shortleaf, loblolly, slash, and longleaf pines.)

BYRAM, G. M., and MARTIN, R. E.
Fire whirlwinds in the laboratory. Fire Control Notes 23(1):13-17, illus.
(Scale model fire whirlwinds can be produced and studied in specially designed cylindrical enclosures.)

CAMPBELL, R. A.
A guide to grading features in southern pine logs and trees. Southeast. Forest Expt. Sta. Paper 156, 23 pp., illus.
(Lists and illustrates the chief grading factors used in determining the quality of southern pine logs and trees.)

CAMPBELL, R. A.
Overruns—southern pine logs. Southeast. Forest Expt. Sta. Res. Notes 183, 2 pp.
(Overrun based on green lumber tally of lumber cut on circle mills is given for Doyle, Scribner, and International ¼-inch log scales.)

CAMPBELL, R. A.
Southern pine lumber grade yields. Southeast. Forest Expt. Sta. Res. Notes 182, 2 pp.
(The percent of lumber expected in each lumber grade from each of the Forest Service standard log grades is given for longleaf and slash pine combined and loblolly and shortleaf combined.)

CAMPBELL, W. A., DARBY, S. P., and BARBER, J. C.
Fusiform rust, an obstacle to the establishment of grafted slash and loblolly pine seed orchards. Ga. Forest Res. Paper 11, 5 pp.
(Grafts made in nursery beds or greenhouses offer a means of controlling rust and increasing the percentage of successful grafts.)

CARTER, M. C., and JONES, LeROY
The effect of hydrogen peroxide on the germination of loblolly and slash pine seed. Southeast. Forest Expt. Sta. Paper 141, 12 pp., illus.
(A 48- to 96-hour soak in 1 percent hydrogen peroxide increased germination of both loblolly pine and slash.)

CECH, F. C., BARBER, J. C., and ZOBEL, B. J.
Comments on "Who Wants Tree Seed Certification and Why?" Jour. Forestry 60:208-210.
(Reviews seed certification programs and illustrates need for better methods of marketing tree seed.)

CHAPPELLE, D. E.
Value growth of pine pulpwood on the George Walton Experimental Forest. Southeast. Forest Expt. Sta. Paper 140, 14 pp., illus.
(Isolates tree characteristics that are useful indicators of future value growth rate and demonstrates the application of financial maturity concepts to longleaf and slash pine pulpwood management.)

CLARK, E. W., and CHADBOURNE, D. S.
A comparative study of the weight, and lipid and water content of the pink bollworm. Annals Ent. Soc. Amer. 55:225-228.
(Statistically no differences in these 3 measurements occurred between boll-reared nondiapause and diapause larvae but differences between boll-reared and square- and bloom-reared larvae did occur. As diapause larvae aged, weight and lipid content decreased but percent of water remained fairly constant. Larvae lived up to 33 months at 15° C., at which time their lipid content was depleted.)

CLARK, E. W., and RICHMOND, C. A.
The effect of aqueous submersion on larval and pupal pink bollworm. Jour. Econ. Ent. 55:167-169.
(Nondiapause and diapause larvae were submersed at 3 temperatures for increasing periods of time until 100 percent mortality was reached. The time required for mortality was inversely proportional to temperature. Both respiration and anaerobiosis were demonstrated.)

CLEMENTS, R. W.
Louisiana pine forests produce liquid gold. Naval Stores Rev. 72(6):4-6, 18.
(Yields were high enough to warrant commercial production.)

CLEMENTS, R. W.
Louisiana slash pine produce good gum yields. AT-FA Jour. 25(1):4-5.
(Gum yields were comparable with those from other parts of the naval stores region.)

COPELAND, O. L., Jr., and McALPINE, R. G.
Soil characteristics associated with spot die-out in loblolly pine plantations. Forest Sci. 8:12-15, illus.
(Spot die-out results from a combination of unfavorable edaphic factors that contribute to excessive root mortality, loss of vigor, and subsequent mortality on less favorable sites.)

COTRUFO, COSIMO
Pretreatment of eastern white pine seed. Southeast. Forest Expt. Sta. Res. Notes 176, 2 pp.
(Response of eastern white pine seed to pretreatment with citric and tartaric acids.)

CUSHWA, C. T.
Forest recreation—how much? Va. Wildlife 23(1): 12, illus.
(Partial results of a sampling study for estimating how much and what kind of recreation is occurring on a 100-square-mile unit of forest land.)

CUSHWA, C. T., and JAMES, G. A.
Measurement of forest recreation use. South. Lumberman 205(2561):150-151, illus.
(Two sampling methods for estimating recreation use on developed recreation sites and undeveloped forest areas.)

DAY, M. W., and BENNETT, F. A.
Percent of height as a measure of density in slash pine plantations. Quart. Bul. Mich. Agr. Expt. Sta., Mich. State Univ. 45(2):325-333.
(Percent of height was found to be a valid measure of density but does not give results that are comparable with basal area or any other measure of stand density.)

DELLA-BIANCA, LINO
Some hydrologic properties of the Cecil and Lloyd soil series in Piedmont forests. Southeast. Forest Expt. Sta. Res. Notes 179, 2 pp.
(Lists soil separates, moisture equivalents, wilting points, bulk densities, percolation rates, detention storage, retention storage, and saturated pore space by horizons.)

DIXON, J. C., and BENJAMIN, D. M.
An evaluation of susceptibility of jack pine forests to defoliation by the jack-pine budworm. Univ. Wis. Forestry Res. Notes 78, 4 pp.
(Susceptibility of jack pine stands is related to density of stocking.)

DORMAN, K. W.
Forest tree improvement for Georgia: a problem analysis of research needs in forest tree breeding and forest genetics. Ga. Forest Res. Council Rpt. 9, 79 pp., illus.
(Comprehensive, long-range program of forest tree breeding and genetics research including racial selection, single tree selection, and several types of hybridization.)

DOUGLASS, J. E.
A method for determining the slope of neutron moisture meter calibration curves. Southeast. Forest Expt. Sta. Paper 154, 6 pp., illus.
(A new volumetric procedure for calibrating neutron moisture probes.)

DOUGLASS, J. E.
Variance of nuclear moisture measurements. Southeast. Forest Expt. Sta. Paper 143, 11 pp., illus.
(Sources of variation in moisture measurement, precision of estimates of total moisture content vs. moisture change, and experimental design for the neutron moisture meter.)

DROOZ, A. T., and SOLOMON, J. D.
A comparison of elm spanworm oviposition habits in 1960 and 1961. Southeast. Forest Expt. Sta. Res. Notes 173, 2 pp.
(When egg mass samples of elm spanworm were compared for position on a host branch and host preference, the distribution patterns for 2 years were nearly identical.)

FONS, W. L., CLEMENTS, H. B., ELLIOTT, E. R., and GEORGE, P. M.
Project fire model—summary progress report—II.
(Distributed to restricted list by National Bureau of Standards.)

HALE, O. M., HUGHES, R. H., and KNOX, F. E.
Forage intake by cattle grazing wiregrass range. Jour. Range Mangt. 15:6-9, illus.
(Daily intake of native forage and total digestible nutrients declined during summer and fall from spring maximums, then dropped abruptly in winter.)

HANEY, G. P.
Growth of thinned white oak sprouts. Jour. Forestry 60: 644-645.
(The increased diameter growth after thinning white oak sprout clumps on sites 50 to 60 is not great enough to offset the loss of cubic-foot growth.)

HANEY, G. P.
A revised shortleaf pine bibliography. Southeast. Forest Expt. Sta. Paper 155, 74 pp.
(Brings Station Paper 48, "Shortleaf Pine Bibliography," up to date.)

HANEY, G. P.
Seedbed scarification aids regeneration of shortleaf pine. Jour. Forestry 60:400-402, illus.
(Scarification quadrupled milacre stocking of shortleaf pine in the North Carolina Piedmont.)

HANEY, G. P., and KORMANIK, P. P.
Cubic-foot volume tables for shortleaf pine in the Virginia-Carolina Piedmont. Southeast. Forest Expt. Sta. Res. Notes 170, 2 pp.
(Cubic-foot volumes of wood plus bark to a 3-inch and 4-inch top d. i. b. for natural shortleaf pine by diameter and total height.)

HARMS, W. R.
Spacing-environmental relationships in a slash pine plantation. Southeast. Forest Expt. Sta. Paper 150, 16 pp., illus.
(Diameter growth among three spacings and relationships to soil moisture, rainfall, evaporation, wind, and soil and air temperature.)

HARMS, W. R., and McGREGOR, W. H. D.
A method for measuring the water balance of pine needles. Ecology 43(3):513-532.
(Describes adaptation of Weatherly's relative turgidity procedure to pine.)

HELVEY, J. D., and HEWLETT, J. D.
The annual range of soil moisture under high rainfall in the Southern Appalachians. Jour. Forestry 60:485-486, illus.
(Interpretation of soil moisture observations suggests that forest vegetation at Coweeta Hydrologic Laboratory rarely if ever suffers true drought. Seasonal soil moisture changes were strongly correlated with changes in streamflow.)

HENDRIX, F. F., Jr., and KUHLMAN, E. G.
A comparison of isolation methods for Fomes annosus. Plant Dis. Rptr. 46(9):674-676.
(The number of wood samples infected by *Fomes annosus*, as well as the depth of penetration into wood, can be determined more accurately by plating than by incubating in moist paper and examining the wood surface for the presence of conidia.)

HENRY, B. W., DORMAN, K. W., and WAKELEY, P. C.
Forest genetics publications by the Southeastern and Southern Forest Experiment Stations. South. Forest Expt. Sta. Occas. Paper 192, 27 pp.
(Annotated bibliography of papers on forest genetics, forest tree breeding, and several closely related fields.)

HEPTING, G. H.
Climate change and forest diseases. Fifth World Forestry Cong. Proc. 2:842-847.
(A consideration of long-range changes in our climate, and how these factors may influence the development and severity of forest tree diseases.)

HEPTING, G. H.
Forestry gains from basic research. Va. Jour. Sci. 13(3): 123-134.
(A review of several types of basic research in forestry.)

HEPTING, G. H.
The top five among forest diseases of the South. Forest World 1(3):35-38.
(The five most serious forest tree diseases in the South, and measures for their control.)

HEPTING, G. H., and FOWLER, M. E.
Tree diseases of eastern forests and farm woodlands. U. S. Dept. Agr. Inform. Bul. 254, 48 pp., illus.
(A comprehensive review of the various diseases occurring on eastern tree species.)

HEPTING, G. H., and NEWHOOK, F. J.
A pine disease in New Zealand resembling littleleaf. Plant Dis. Rptr. 46(8):570-571, illus.
(Description of a disease condition of Monterey pine in New Zealand closely resembling littleleaf disease of shortleaf pine in the United States.)

HILMON, J. B., and LEWIS, C. E.
Effect of burning on south Florida range. Southeast. Forest Expt. Sta. Paper 146, 12 pp., illus.
(Trends in yield, chemical content, and species composition of native herbage were followed over a 2-year period after a February fire.)

HODGES, C. S.
Black root rot of pine seedlings. Phytopathology 52(3): 210-219, illus.
(Field isolations and greenhouse inoculations indicate *Sclerotium bataticola*, alone or in combination with *Fusarium* spp., causes black root rot.)

HODGES, C. S.
Comparison of four similar fungi from Juniperus and related conifers. Mycologia 54(1):62-69, illus.
(The taxonomy, host range, and distribution of *Cercospora sequoiae* var. *juniperi*, *C. sequoiae*, *Stigmina juniperina*, and *S. glomerulosa*.)

HODGES, C. S.
Diseases in southeastern forest nurseries and their control. Southeast. Forest Expt. Sta. Paper 142, 16 pp., illus.
(Descriptions and control of the more common diseases of seedlings of forest trees in southern nurseries.)

HODGES, C. S.
Fungi isolated from southern forest tree nursery soils. Mycologia 54(3):221-229.
(A listing of various fungi isolated from soil samples collected in 30 forest nurseries in 10 southern states.)

HODGES, C. S., and HAASIS, F. A.
Etiology of Cercospora leaf spot of magnolia. Mycologia 54(4):453-454.
(Cross inoculation studies with isolates of *Cercospora magnoliae* from *Magnolia grandiflora* and *M. virginiana* produced leaf spot symptoms typical for the respective host regardless of source of inoculum. The taxonomy of the causal organism is discussed and an emended description of the species is given.)

HOEKSTRA, P. E., and ASHER, W. C.
Diameter growth of pole-size slash pine after fertilization. Jour. Forestry 60:341-342, illus.
(Radial growth response to a 7-7-7 fertilizer on a Plummer soil was greater than response to 3-18-6 fertilizer. Radial growth with 7-7-7 applied at 20 pounds per tree was 126 percent of the control.)

HUGHES, R. H., and JACKSON, J. E.
Fertilization of young slash pine in a cultivated plantation. Southeast. Forest Expt. Sta. Paper 148, 14 pp., illus.
(Phosphate at 50-pound rate was the most efficient fertilizer tested. Rapid growth stimulated by cultivation and fertilization apparently increased the susceptibility of plantation trees to insects and diseases.)

IKE, A. F., Jr.
Fertilized yellow-poplar seedlings maintain growth advantage after four years. Southeast. Forest Expt. Sta. Res. Notes 175, 2 pp.
(Fertilized seedlings showed increase in height growth each year over unfertilized seedlings.)

IKE, A. F., Jr.
Fertilizer nearly doubles Georgia sycamore growth. Crops and Soils 15(3):16.
(Properly prepared and fertilized, sycamore seedlings will survive and outgrow weeds that often defeat old-field plantations.)

IKE, A. F., Jr.
Root collar diameter is a good measure of height growth potential of sycamore seedlings. Tree Planters' Notes 54: 9-11, illus.
(Mean first-year height growth of seedlings with root collars of various diameters.)

JOHANSEN, R. W.
Establishing seedlings on borate-treated areas. Forest Farmer 21(12): 17, illus.
(Slash pine seedlings can be planted successfully on borate-treated areas after double-disking.)

JOHNSON, F. M., LINDZEY, JAMES, and RIPLEY, T. H.
Recent developments and needs in game and game habitat research in connection with pine site preparation. Fifteenth Ann. Conf. Southeast. Assoc. Game and Fish Commrs. Proc. 1961:27-29.
(Recent developments in game and game habitat research relating to preparation of pine sites for planting.)

JONES, E. P., Jr.
Profit from wasteland. Forest Farmer 21(11):8.
(A case study of products removed and residual stand values in a 33-year-old slash pine plantation in the middle coastal plain of Georgia.)

JONES, LeROY
Recommendations for successful storage of tree seed. Tree Planters' Notes 55:9-20.
(Recommendations for seed storage of approximately 79 species based on literature, observations, and research at the Eastern Tree Seed Laboratory.)

JONES, LeROY
Solving tree seed problems: the role of the Eastern Tree Seed Laboratory in southern forestry. South. Lumberman 205(2561):133-134, illus.
(Describes services and activities of the Eastern Tree Seed Laboratory located near Macon, Georgia.)

JONES, LeROY, BARBER, J. C., and MABRY, J. E., Jr.
(Abs.) Effect of methyl bromide fumigation on germination of southern pine seed. Tree Planters' Notes 55:25.
(Results show that both moisture content and dosage level are important in fumigating longleaf, slash, and loblolly pine seed.)

KELMAN, ARTHUR, HODGES, C. S., and GARRISS, HOWARD
Needle blight taking toll of Christmas trees. Research and Farming 20(3-4):6.
(Symptoms and control measures of needle blight of eastern redcedar.)

KORMANIK, P. P., and HANEY, G. P.
International ¼-inch board-foot volume table for shortleaf pine in the Virginia-Carolina Piedmont. Southeast. Forest Expt. Sta. Res. Notes 178, 2 pp.
(Board-foot volumes by diameter breast high and total height to a top d. i. b. of 6 inches.)

KORMANIK, P. P., and LITTLE, E. L., Jr.
Trees and shrubs of the Lee Experimental Forest. Southeast. Forest Expt. Sta., 12 pp.
(Descriptions of the trees, shrubs, and vines found on the Forest.)

KOWAL, R. J.
The elm spanworm—past, present, and future. Fifteenth Ann. Conf. Southeast. Assoc. Game and Fish Commrs. Proc. 1961:178-185.
(History of elm spanworm outbreaks, research in chemical and biological control, future trend of the epidemic, and possibilities for control.)

KUHLMAN, E. G., and HENDRIX, F. F., Jr.
A selective medium for the isolation of Fomes annosus. Phytopathology 52:1310-1312, illus.
(A new agar medium permits direct isolation of *Fomes annosus* from infected host tissue. Associated saprophytic fungi and bacteria are inhibited on this medium, while *F. annosus* grows normally.)

KUHLMAN, E. G., HENDRIX, F. F., Jr., and HODGES, C. S.
Inoculation and colonization of stumps of Pinus echinata by Fomes annosus. (Abs.) Phytopathology 52(8):739.
(Results of a large-scale stump inoculation test using three types of inoculum of *Fomes annosus*. Gives percentage of colonization and depth of penetration of stumps by the fungus.)

LANGDON, O. G.
Ridge planting improves early growth of South Florida slash pine. Jour. Forestry 60:487, illus.
(Combined results of two studies at 5 years showed that a slightly elevated ridge planting position had superior growth in both studies and better survival in one.)

LARSON, P. R., DUFFIELD, J. W., DORMAN, K. W., and others. (Subcommittee on Forest Biology Committee.)
The influence of environment and genetics on pulpwood quality: an annotated bibliography. TAPPI Monog. Series 24, 316 pp.
(A comprehensive review of world literature.)

MATTHEWS, F. R.
Pitch canker-tip moth damage association on slash pine seedlings. Jour. Forestry 60:825-826.
(The tip moth may play an indirect role in spreading pitch canker fungus by establishing an infection count when it feeds on the shoots.)

MERKEL, E. P.
The number of larval instars of *Dioryctria abietella* (D. and S.) (Lepidoptera: Phycitidae) in Florida. Canad. Ent. 94:1005-1007, illus.
(Methods for determining larval instars of *D. abietella* and Comparison of Florida and Canadian larvae head-capsule width data for this insect.)

MERKEL, E. P.
The toxicity of insecticides to larvae of *Dioryctria abietella* in laboratory screening tests. Jour. Econ. Ent. 55:682-684, illus.
(Laboratory procedures for evaluating toxicity of 13 insecticides to last-instar larvae of the coneworm, *D. abietella*, and concentration-mortality data.)

MOORE, W. H., and MANNEY, R. B.
Deer browse plants in loblolly and water oak-gum types of Piedmont Georgia. Southeast. Forest Expt. Sta. Res. Notes 172, 2 pp.
(Species composition of understory vegetation is clearly related to forest types. Sampling techniques provide data on types most desirable as deer browse.)

PAGE, R. H.
Kerf chips—good or bad? South. Lumberman 205(2552): 43-44.
(How kerf chips are made, production at 19 southeastern pine mills, economics of production, and mill operators' reaction.)

PAGE, R. H., and PERRY, J. H., Jr.
Pretreating turpentined longleaf pine poles to improve penetration and retention of creosote. Southeast. Forest Expt. Sta. Paper 152, 13 pp., illus.
(Compares 4 methods of pretreating scar-faces of longleaf pine.)

PAGE, R. H., and RODENBACH, R. C.
Comparison of yield in clear and usable cuttings from different grades of maple lumber. Furniture, Plywood and Veneer Council of the N. C. Forestry Assoc., Inc., Rpt. 9, 2 pp.
(Compares yield of usable and clear cuttings from 1 Common and better with 2 Common hard and soft maple lumber at one N. C. furniture plant.)

PAGE, R. H., and WHITE, J. F.
Break-through in sawmilling—exit sawdust. South. Lumberman 205(2561):103-104, illus.
(Describes operation of a prototype model of the "Griff-saw.")

PECHANEC, J. F.
U. S. Forest Service builds new research lab on campus. The Cypress Knee. Univ. Ga. School Forestry, p. 34.
(Research facilities planned for utilization, disease, insects, and management.)

PERRY, J. H., Jr.
Prescribed burning on the Olustee. Forest Farmer 21(9): 12-13, 17, 19.
(Experiences and techniques learned in nearly 20 years of prescribed burning at the Olustee Experimental Forest in north central Florida.)

PETER, RALPH, and BAMPING, J. H.
Theoretical sawing of pine logs—a new technique for evaluating sawing methods. Forest Prod. Jour. XII (11): 549-557, illus.
(A method for theoretically sawing the same log an infinite number of times to obtain data for evaluating sawing methods.)

PHARIS, R. P., BARNES, R. L., and NAYLOR, A. W.
Effects of nitrogen level, calcium level, and nitrogen source upon the growth and composition of loblolly pine. (Abs.) Plant Physiol. Proc. 37 (Sup.):xlix.
(Nitrogen content of foliage was greatest in urea seedlings, least in nitrate. Nitrogen source, however, was not a major influence in total nitrogen content of roots.)

POWERS, H. R., Jr., and VERRALL, A. F.
A closer look at Fomes annosus. Forest Farmer 21(13): 8-9, 16-17, illus.
(Reviews South-wide *Fomes annosus* survey and gives results and correlations between certain site and stand characteristics and annosus infection.)

RALSTON, C. W., and McGEE, C. E.
Planting turkey oak sites with slash pine may not pay. Jour. Forestry 60:719-720, 722, illus.
(Lands with a site index of 30 feet at 25 years, the average for deep-sand turkey oak areas, are submarginal for slash pine.)

RIPLEY, T. H.
Recreation impact on Southern Appalachian campgrounds and picnic sites. Southeast. Forest Expt. Sta. Paper 153, 20 pp., illus.
(Sampling of 42 developed camping and picnic sites in the Southern Appalachians suggests important management guides such as location, planning, and rehabilitation.)

RIPLEY, T. H.
Tree and shrub response to recreation use. Southeast. Forest Expt. Sta. Res. Notes 171, 2 pp.
(Conifers and hardwoods listed in order of decreasing ability to withstand impacts of recreation use, as gaged by disease infection, insect infestation, and decline.)

ROBINSON, V. L.
1961 pulpwood prices in the Southeast. Southeast. Forest Expt. Sta. Res. Notes 181, 2 pp.
(All-wood prices were $16.55 per cord for rough pine pulpwood and $13.50 per cord for hardwood. Chips were $6.50 and $4.95 per ton for pine and hardwoods, respectively.)

ROBINSON, V. L., and NICHOLS, A. C.
Southern pulpwood production, 1961. Southeast. Forest Expt. Sta. Forest Survey Release 59, 26 pp., illus.
(Round pulpwood and pulp chips from wood residues, by pine and hardwood species groups and by State; also, roundwood by county.)

RODENBACH, R. C., and OLSON, D. F., Jr.
Five-year survival and height growth of several planted hardwood species in the North Carolina Piedmont. Furniture, Plywood and Veneer Council of the N. C. Forestry Assoc., Inc., Rpt. 10, 5 pp.
(A majority of the 17 species tested in two demonstration arboretums showed good survival, but height growth was satisfactory on only a few species.)

ROMANCIER, R. M., and BRENDER, E. V.
Management of small woodland holdings in the Georgia Piedmont, a 12-year report. Southeast. Forest Expt. Sta. Paper 151, 12 pp., illus.
(A 12-year case study of three woodlots, emphasizing growth and income.)

ROMANCIER, R. M., and LeGRANDE, W. P.
Glaze damage on the Santee Experimental Forest. South. Lumberman 205(2561): 99-100, illus.
(Describes loblolly damage and proposes classification to guide salvage cutting.)

RUEHLE, J. L.
Histopathological studies of pine roots infected with lance and pine cystoid nematodes. Phytopathology 52(1):68-71.
(Microscopic examinations of pine roots invaded by parasitic nematodes. Lance and pine cystoid nematodes were found to damage roots of slash and loblolly pine severely.)

RUEHLE, J. L.
Plant-parasitic nematodes associated with shortleaf pine showing symptoms of littleleaf. Plant Dis. Rptr. 46(10): 710-711.
(Two species of nematodes consistently found in healthy and diseased stands were twice as abundant in diseased stands.)

RUEHLE, J. L., and SASSER, J. N.
The role of plant-parasitic nematodes in stunting of pines in southern plantations. Phytopathology 52(1): 56-68.
(Several parasitic species of nematodes were found associated with stunted loblolly and slash pine in plantations. Greenhouse inoculations showed that pine cystoid nematodes caused considerable root damage, but did not decrease growth as markedly as lance nematodes.)

SMITH, W. R.
The structure and properties of wood as related to utility poles. Tenn. Valley Wood Pole Conf. Proc. 1962:12-23.
(Properties of wood, growth, abnormal wood, pole classes, and relation of defects and moisture content to poles.)

SMITH, W. R.
Wood against the March northeaster. Forest Prod. Jour. XII(9):16A, illus.
(Compares damage from a northeaster to homes built of wood with those built of masonry blocks and other material.)

SOLOMON, J. D.
Characters for determining sex in elm spanworm pupae. Jour. Econ. Ent. 55:269-270, illus.
(Characters found useful in distinguishing the sex of elm spanworm pupae are location of the genital opening, elevation of the antennae, color, size, and a behavioral difference. Location of genital opening was the most reliable character for separating sexes.)

SOUTHEASTERN FOREST EXPERIMENT STATION
Annual report for 1961. 81 pp., illus.
(Highlights of the Station's research results.)

SPEERS, C. F.
Fraser fir seed collection, stratification, and germination. Tree Planters' Notes 53:7-8.
(Germination increased the longer cone collections were delayed. Stratification increased speed but not amount of germination.)

SQUILLACE, A. E.
Breeding for high-gum yield in slash pine. Naval Stores Rev. 72(9):7, 17.
(Selection and controlled crossing have created a strain with over twice the average yield.)

SQUILLACE, A. E., ECHOLS, R. M., and DORMAN, K. W.
Heritability of specific gravity and summerwood percent and relation to other factors in slash pine. TAPPI 45(7): 599-601.
(In 14-year-old trees heritability of specific gravity was 21 to 56 percent and in clones 73; summerwood percent was 8 to 56 and 48, respectively.)

SQUILLACE, A. E., and SILEN, R. R.
Racial variation in ponderosa pine. Soc. Amer. Foresters, Forest Sci. Monog. 2, 27 pp.
(Analyses of two studies—one of 30 and the other 45 years' duration—verify apparent differences in growth rate, and correlate them with geographic and climatic factors.)

STUBBS, JACK
Wetland forests. Forest Farmer 21(11):6-7, 10-13, illus.
(Description, opportunities, and problems of wetland forests in the Atlantic coastal plain.)

TALERICO, R. L., and HEIKKENEN, H. J.
Stem injury to young red pine by the European pine shoot moth. Jour. Forestry 60:403-406, illus.
(Describes the type and amount of injury to young red pine after severe infestation by the shoot moth and a method for identifying past shoot moth outbreaks.)

TODD, A. S., Jr., and YOHO, J. G.
Forestry in the southern economy. Jour. Forestry 60:694-704, illus.
(Forest products contribute $3.9 billion a year to the economy of the South, ranking second only to textiles in employment provided and value added by manufacture.)

VIMMERSTEDT, J. P.
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Addenda

The following items were omitted from the Station's 1961 Bibliography:

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